PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA

FOR

PROMOTING USEFUL KNOWLEDGE.

Vol. XVII.

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AMERICAN PHILOSOPHICAL SOCIETY,

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VOL. XVII. MAY TO DECEMBER, 1877. No. 100.

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AMERICAN PHILOSOPHICAL SOCIETY,

1878.

JANUARY 4, ANNUAL ELECTION OF OFFICERS,

Between the hours of 2 and 5 o'clock, P. M.

STATED MEETINGS OF OFFICERS AND COUNCIL.	STATED MEETINGS OF SOCIETY 7 o'clock, P. M.	STATED BUSINESS OF THE MEETING. (*Chair taken at 8 o'clock.*)
	Jan. 4.	Election of officers reported. Librarian nominated.
	Jan. 18.	Librarian and Standing Committees chosen. Catalogue of members read. Candidates for membership balloted for.
	Feb. 1.	
Feb. 8.		
	Feb. 15.	Proceedings of Officers and Council submitted.
	Mar. 1.	
	Mar. 15.	
	April 5.	
	April 19.	Candidates for membership balloted for.
	May 3.	
May 10.		
	May 17.	Proceedings of Officers and Council submitted.
	June 21.	
	July 19.	Candidates for membership balloted for.
Aug. 9.		
	Aug. 16.	Proceedings of Officers and Council submitted.
	Sept. 20.	
	Oct. 4.	
	Oct. 18.	Candidates for membership balloted for.
	Nov. 1.	
Nov. 8.		
	Nov. 15.	Proceedings of Officers and Council submitted.
	Dec. 6.	Reports of Treasurer and Publication Committee. Communications for Magellanic Premium considered at this or the next stated meeting.
	Dec. 20.	Report of Finance Committee. Appropriations for the succeeding year passed.

OFFICIATING SECRETARIES AND CURATORS.

Secretaries.—J. L. LECONTE, P. E. CHASE, for January, March, May, July, September, November.

G. F. BARKER, J. P. LESLEY, for February, April, June, August, October, December.

Curators.—HECTOR TYNDALE, for January, April, July, October.

CHARLES M. CRESSON, for February, May, August, November.

DANIEL G. BRINTON, for March, June, September, December.

☞ 1879. January 3, ANNUAL ELECTION OF OFFICERS, between the hours of 2 and 5 o'clock, P. M.

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY.

VOL. XVII. JUNE TO DECEMBER, 1877. No. 100.

Stated Meeting, May 20th, 1877.

Present, 12 members.

Vice-President, Mr. PRICE, in the Chair.

Prof. Geo. Stuart and Dr. Rothrock, newly-elected members, were introduced to the presiding officer and took their seats.

A letter accepting membership was received from Mr. J. Douglass, dated Phœnixville, Pa., May 8, 1877.

Letters of envoy were received from the R. Academy at Amsterdam, December 1, 1876, and from the U. S. Department of the Interior at Washington.

Letters of acknowledgment were received from the R. A. Amsterdam, January 6, 1877 (95, 97); B. S. N. H., May 10, 1877 (96, 98); Dr. Green, Lib. Rensselaer Pol. Inst., May 11, 1877 (Cat. I–II.).

Donations were received from the R. A., Amsterdam; Ger. Geol. Soc., Berlin; Zool. Gart. Frankfort; N. H. S. Leipsig; R. A. d. L., Rome; Vaudois Soc. Lausanne; Geog. Soc. and Rév. Pol. Paris, and Nov. Met.; B. H. N. S.; Mr. Hubert Howe Bancroft, of New York; Mr. W. E. Dubois; Penn Monthly; Med. News and Lib. Philadelphia; Coms. 2d Geol. Sur. Pa.; Howard University, Washington, D. C.;

U. S. Dep. Interior; Botanical Gazette, Logansport, Ind.; Kansas State Hist. Soc.; Mr. H. S. Scudder and Mr. Archibald Liversidge, Sydney, Australia.

Prof. Cope presented a communication for the Proceedings entitled, "On the Reptilian Bone Bed in East Illinois. By E. D. Cope;" illustrated the interesting points of the paper, and the doubtful character of the horizon of the formation from which the remains were obtained; but leaned to the view that it was of Permian age. The vertebræ of these reptiles are perforated, showing the existence of a *chorda dorsalis*, a character unknown in living animals except in one New Zealand genus.

Prof. Cope communicated also a paper "On some new and little known reptiles and fishes, from the Austro-riparian region of the United States;" explaining the boundaries of the region, &c.

Nominations 836, 837, 838, were read.

And the meeting was adjourned.

Stated Meeting, June 15th, 1877.

Present, 17 members.

Vice-President, Mr. FRALEY, in the Chair.

Dr. Morehead, a newly elected member, was introduced to the presiding officer and took his seat.

Letters of envoy were received from the Observatory at Turin, dated May 17; the Obs. Harvard Coll., June 5; and the Department of the Interior, May 27, 1877.

Letters of acknowledgment were received from the Asiatic Society of Japan (93 to 97); the R. Acad. Linc., Rome (XII, XIII, i, ii, XIV, XV, i, ii, and Proc. Vols. 8 to 14); Institute of Luxembourg, May 5 (95, 97); R. Astron. Society, May 9 (96, 98); Soc. of Antiquaries, London, May 11 (96, 98); London Statistical Society, May 11 (96, 98); and the Victoria Institute, May 8 (96, 98).

Donations for the Library were reported from the Mining Bureau at Melbourne; School of Mines at Ballarat; R. Danish Society; Imp. Academies at Berlin, Vienna and Bruxelles; the Scientific Club at Vienna; Art Union at Ulm; R. Observatory at Turin; M. Aless. Dorna; R. Acad. at Rome; M. F. De Saussure and Rev. Pol. Paris; R. Society, R. Institution, R. Ast. Society, Meteor. Committee, and Nature, London; Lord Lindsay; Canadian Journal of Sciences, Toronto; B. S. N. History; Observatory at Harvard College; Amer. Chemist; Franklin Institute, Acad. Nat. Sciences, Jour. Pharmacy, Med. News, Penn Monthly, and Zoological Society at Philadelphia; Prof. E. D. Cope; Mr. Horace W. Smith; Mr. Joel A. Allen; the U. S. Fish Commission; U. S. War Department; Mr. Edwin A. Barber; Botanical Gazette of Logansport, Ind.; Wisconsin State Historical Society; M. Barcena, of Mexico; and Silliman's Journal.

A copy of the Proceedings, No. 99, just published, was laid upon the table.

The death of Mr. Edmund Quincy, a member of the Society, was announced by the Secretary.

Dr. Sadtler read a paper entitled, "Dichlorsalicylic Acid, by Dr. Edgar F. Smith, Ph.D."

Pending nominations Nos. 836, 837, 838, were read.

The chairman of the Committee on the Wootten process, Dr. R. E. Rogers, read the following report:

The Committee to whom was referred the examination of Mr. John E. Wootten's method of utilizing coal dirt from the waste heaps in the anthracite mining regions by the Resolution of the Society of November 17, and December 1, 1876, respectfully report:

Unanimously, that the method of Mr. Wootten as exhibited to them is meritorious and successful.

But they disagree as to its originality; and they therefore prefer to refer the question of the award of the premium to the Society.

Signed by R. E. Rogers, Wm. A. Ingham, J. Blodget Britton, Robert Briggs and Geo. F. Barker.

After a full statement of their individual opinions had been made by the members of the Committee who were present,

Dr. Rogers moved the following Resolution:

Resolved, That in view of the originality, merit and success of Mr. Wootten's process for utilizing coal waste, Mr. Wootten be awarded the premium above referred to.

After discussion on which resolution it was

Resolved, That the Report be recommitted to the Committee, with instructions that all competing methods be considered by the Committee which shall be presented to its consideration within three months after public advertisement by the Society in two city papers once a week for three weeks; the function of the Committee being clearly understood to be to report on the success, the originality, and the merits* of the process.

And the Society was adjourned at 11 o'clock, P. M.

Stated Meeting, July 20th, 1877.

Present, 16 members.

Vice-President, Mr. FRALEY, in the Chair.

Prof. H. Draper, a newly-elected member, was introduced to the presiding officer and took his seat.

Visitor, Mr. Wallace, of Ansonia, Conn.

A photograph of Mr. Sears C. Walker was received from the Smithsonian Institution, for the album.

Letters of acknowledgment were received from the R. S. of Tasmania, Dec. 27, 1876 (92, 93, 94); R. D. A. Copenhagen, June 16, 1877 (96, 98); N. H. Union at Bremen, July 1, 1877 (96,* 98) (* asks for 97 not received); A. d. L. Rome (97); Trübner & Co, London, June 29, 1877 (96,* 98); N. Hampshire Hist. Soc. July 2, 1877 (99); and the Chicago Hist. Soc. June 14 and 29, 1877 (94, 95, 96, 97, 98).

Letters from the R. Acad. Berlin, June 15, July 2, were received, requesting missing pages Proc., Vol. VII, pp. 121–163, and Vol. IX, 1870, plates 6, 7, 8.

A letter from the Bureau of Education, Washington, D. C., was received, requesting replies to inquiries respecting meetings and publications.

* Mr. Briggs wished the attention of the Society to be drawn to a clerical error in the printed Proceedings of December 1, 1876, whereby the word "merits" was omitted.

Letters of envoy were received from the R. Norw. University; K. K. Z. B. G. Vienna; N. G. Bamburg; and the U. S. Depart. Interior, Washington.

Donations for the Library were received from the R. S. Tasmania; Phys. C. Obs. St. Petersburg; R. Nor. Univ. Christiania; K. K. Geol. R. Vienna; Anthro. G. and K. K. Z. B. G. Vienna; D. Geol. G. Berlin; K. L. C. A. D. N. Dresden (with a letter requesting a renewal of the old correspondence*); Ed. Haus und Landwirthschaft Kalendar, Munich; V. f. K. u. A. Ulm; N. H. G. Bamburg; A. d. L. Rome; Portuguese Commissioners to the Centennial Exhibition; S. de Geog., Ed. Annales des Mines, and Révue Politique, Paris; R. A. Brussels; Astronomical Society, Royal S. of Antiquaries, Zoological Society, and Nature, London; R. Cornwall Pol. Society; N. H. S. Newcastle-upon-Tyne; Director of Geol. Survey, Canada; Ed. Canadian Journal of Science; Essex Institute; A. Acad. A. and S.; Boston N. H. S.; Mass. State Board of Health; S. H. Scudder, Cambridge; Ed. Science Observer, Boston; Am. Jour. Science and Arts; Yale College; Geol. Survey New York, Prof. Hall, Albany; Young Men's Association, Buffalo; Acad. N. S. Philadelphia; Franklin Institute; Jour. of Pharmacy; Jour. of Med. Sciences; Med. News and Library; Penn Monthly; E. D. Cope, Philadelphia; Peabody Institute, Baltimore; Dep. Int. Washington; Chicago Acad. Sciences; Ed. Botanical Gazette, Ind.; M. Barcena, Mexico.

* On motion of Dr. LeConte, it was resolved that the Kais. Leopold. Carol. Academie at Dresden be restored to its place on the list of correspondents, and that it be supplied with all missing volumes of Transactions and numbers of Proceedings as far as possible. (See Mar. 3, 1876.)

Dr. Draper read and explained a paper, entitled "Discovery of Oxygen in the Sun by Photography, and a new theory of the Solar Spectrum, by Prof. Henry Draper, M.D."

Prof. Barker expressed his pleasure at hearing this paper, which in his opinion was the most important contribution

to Solar Physics made in America in this century. Granting the fact of the existence of *bright* lines in the solar spectrum, and no one after seeing Prof. Draper's photographs on collodion could doubt the fact, all the new views expressed in this paper follow as a matter of course. The bright lines are not only clearly apparent when looked for, but are numerous.

Mr. Chase joined in the tribute of merited admiration for Dr. Draper's brilliant discoveries, and suggested that a possible explanation for the different action of different elements might be found in differences of density and elasticity.

W. M. Hicks (L. E. and D. P. Mag, June 1877), by special assumptions, and by a mistake in calculation (see his note in P. Mag. July 1877), obtains the ratio $\frac{e'}{e} = 1.423$. He says: "If, then, the two atoms of a molecule have separated, there seem only two ways of accounting for it. Either their relative motion becomes so large as to overcome the force of attraction, or some external force must act upon them, which can be nothing less than a reaction between them and some other molecule. The latter is the hypothesis I have adopted in the following investigation." My own ratio, based on relative motions (Proc. Am. Phil. Soc., xiv., 651), is $\frac{e'}{e} = 2\,\pi^2 \div (\pi^2 + 4) = 1.423$. This coincidence is, of course, purely accidental, but it is none the less curious. The reasoning upon which it was based seems to justify both my own views of the kinetic energies in perfect gases, and Hicks's view of the importance of temperature relations in coercible gases.

In a mass, like the Sun, which is presumably at or near the point of dissociation, gaseous permanence and gaseous density would both contribute to a change of elliptic into linear radial oscillations, which would have acquired their mean velocity at points ranging between about 180,000 miles, and 260,000 miles above the Sun's surface. It is, therefore, quite possible, especially if hydrogen is metallic, that oxygen, carbon, and other non-metals, may have greater centrifugal tendencies than hydrogen and metallic vapors. Perhaps spectroscopic observations near the Sun's poles may present some contrasts with equatorial observations, which will help towards a settlement of the question.

Prof. Barker communicated a "Note on the exactitude of the French normal fork; a reply to the paper of Mr. A. J. Ellis; by Rudolph König, Ph.D," of Paris; and said that the matter was one of great importance; for if Mr. Ellis' attack could be sustained no confidence could be placed in

and therefore no use could be made by physicists of the large and valuable instruments in the physical laboratory of the University of Pennsylvania made by Dr. König, of Paris. He was happy, therefore, to be able to place on record so complete a refutation of the unwarranted assertions of Mr. Ellis by the aid of Prof. Helmholtz and Prof. Meyer of Hoboken.

Prof. Lesley communicated a paper, entitled "Note on the probable derivation of *Μαζαρις* from the Egyptian formula *Mazeru* after proper names," and explained his views of the appearance of such sacerdotal terms in early times on the monuments of Egypt and in later times in the literature of Greece and Rome. He suggested the possible etymology of *ολβιος*, *ολβιοδαιμων* (=*ενδαιμων*) from the Egyptian *alp*, *arp*, vine, wine, in the sense of *jucundus*, joyous; while *μαζαρ* corresponded to the Hebrew *barak*, *beatus*, blessed. In like manner the *tat* of the monuments reappears in the Latin *tutus*, safe, secure, permanent, unshakeable, and possibly in *totus*, the cosmos, or established order, &c.

Prof. Chase suggested a mode of reaching the demonstration of bright lines in the solar spectrum by mathematical relations between four elementary formulæ of the solar system based on the nebular hypothesis.

Prof. Cope communicated two papers, entitled, "On a new species of Adocidæ from the Tertiary of Georgia;" and "Tenth Contribution to the Herpetology of Tropical America; by E. D. Cope."

Upon a report from Mr. E. K. Price, Chairman of the Committee on the Michaux Legacy, it was

Resolved, That three copies of the Journal of Forestry be subscribed for, out of the Michaux Legacy; one for the Society; one for the Professor of Botany, Lecturer in the Park; and one for the use of the Committee on the Michaux Legacy.

On motion of Prof. Barker, a vote of thanks was passed to Prof. Draper for the gift of the excellent illustrations accompanying his paper.

Pending nominations Nos. 836, 837, 838, were read and

ballotted for, and on a scrutiny of the ballot boxes, the following persons were declared duly elected members of the Society:

Mr. H. C. Humphreys, Chemist, of Philadelphia.

Prof. I. I. Sylvester, of Johns Hopkins Univ., Baltimore.

Mr. John Ericsson, of New York.

And the meeting was adjourned.

Stated Meeting, August 17th, 1877.

Present, 8 members.

Secretary, Dr. LeConte, in the Chair.

Letters acknowledging the receipt of Proceedings, 94 to 99, were received from the R. Observatory at Greenwich; the Radcliffe Observatory; Philosophical Society of Liverpool; the East Tennessee University; Poughkeepsie N. H. Society; Wisconsin Hist. Society; Library of Congress; Public Library of New Bedford; Library of Yale College; Northern Academy of Hanover, Ind.; U. S. Coast Survey Office; American Journal at New Haven; Linnean Society at Lancaster; Buffalo N. H. Society; Prof. L. Rütimeyer, John L. Campbell, C. F. Brackett, C. E. Dutton, W. A. Hammond, E. Goodfellow, T. L. Kane, Thomas Hill, P. F. Rothermel, R. S. Williamson, Jos. LeConte, John LeConte, Cleveland Abbe, J. F. Clarke, Joseph Henry, M. F. Longstreth, Jas. D. Dana, and C. A. Young, now of Princeton.

Donations for the Library were received from the R. Academies at Berlin and Brussels; the Antiquarian Society at Copenhagen; M. Chabas; M. L. Hugo; the Geographical Society and Révue Politique, Paris; the Observatories at Madrid, Mexico, Buenos Ayres and Cordoba; the R. Astronomical and Zoological Societies and London Nature; the Philosophical Society at Glasgow; the Canadian Naturalist; Government of Canada; Peabody Museum at Cambridge; Appalachian Club; American Antiquarian Society; Whelpley and Storer; Silliman's Journal; Mercantile Library of

New York; N. J. Hist. Society; Franklin Institute; Jour. of Pharmacy; News and Library; Penn Monthly; Mr. T. Meehan; U. S. Weather Bureau; Botanical Gazette, Hanover, Ind.; B. S. Lyman, Tokei; and Prof. A. Liversidge, of Sydney, N. S. W.

The death of Prof. Dr. Frederick August Tholuck, at Halle an der Saale, June 10, aged 78 years, was announced, with remarks by the Secretaries.

The death of W. Timothy Abbot Conrad, in Trenton, N. J., August 8, aged 73 years, was announced, with remarks by Prof. Cope.

Dr. Genth read his eleventh contribution from the Laboratory of the University of Pennsylvania, entitled "On Some Tellurium and Vanadium Minerals; by F. A. Genth."

Prof. Cope exhibited and described some recently discovered fossils, one of which was a cast of a gar-pike, of supposed late tertiary date, to which he assigned the provisional name, *Clastes cuneatus*—a possible link between the extinct and living genera of that family.

He communicated also a paper, entitled "On some new or little known Reptiles and Fishes of the Cretaceous, No. 3, of Kansas, by E. D. Cope."

Mr. Briggs added some points to his previous paper on the *Vena contracta*, and made some remarks on the omission from text-books of the elementary fact that, whereas an unsystematically balanced fly-wheel runs steadily and without injury to its housings so long as its rate of rotation suffers no change, the contrary is the case when its rate is retarded or accelerated.

The minutes of the last meeting of the Board of Officers and Members in Council were read, and it was then, on motion,

Resolved, That the thirteen applications for the premium for a coal-dirt burning apparatus offered by the Society, thus far received, be referred to the Committee considering the award of the premium; and that the Committee be requested to prepare a proper form of advertisement in accordance with a recent resolution of the Society.

On motion it was ordered that the name of the Daven-

port Academy of Sciences be placed on the List of Correspondents to receive the Proceedings from the year 1870 onwards.

And the meeting was adjourned.

Stated Meeting, September 21st, 1877.

Present, 12 members.

Vice-President, Mr. FRALEY, in the Chair.

Visitor, Mr. A. E. Carpenter, of Philadelphia.

Letters accepting membership were received from Mr. John Ericsson, dated New York, July 1; from Mr. H. C. Humphrey, dated Seabrook, Conn., August 10; from Prof. J. J. Sylvester, dated St. John's College, Cambria, August 11; from Prof. James Geikie, Perth, Scotland, August 14, 1877.

A photograph for the Album was received from Mr. James Geikie.

Letters of acknowledgment were received from Prof. Steenstrup, Copenhagen, August 31 (99); Royal Zoological Society, Amsterdam, July 14 (96, 98); M. Henri de Saussure, Geneva, August 15 (96, 98); Bureau des Longitudes, Paris, July 18 (96, 98); Royal Society, Edinburgh, August 8 (96, 98); Natural History Society, Northumberland, &c., August 22 (96, 98).

Letters of envoy were received from the Royal Society of New South Wales, July 11, 1877; S. de Geographie Commerciale de Bordeaux, June 1; Meteor. Office, London, July, 1877; Mr. H. S. Eddy, Cincinnati, Ohio, August 28.

A letter was received from Mr. Ludwig Mejer, Secretary of the Natural History Society of Hanover, informing the Society, that Nos. 96 and 98, sent to Prof. Stromeyer, had been given on the death of that member of the Society to the Society in Hanover, and requesting that the gift be confirmed, and the transmission of Proceedings be continued on the basis of exchanges.

On motion the title of the Nat. His. Society of Hanover was ordered to be placed on the list of Corresponding Societies to receive the Proceedings.

Donations for the Library were received from the Department of Mines, Victoria, N. S. W.; Imp. R. Academies at Berlin, Rome and Brussels; the Society at Augsburg; Geographical Society and Annales des Mines, and R. Politique at Paris; Society of Antiquaries; Nature and Cobden Club, London; Boston S. N. H.; Silliman and Dana; College of Physicians, Penn Monthly, Franklin Institute, Amer. Jour. of Pharmacy, Medical News, and E. D. Cope, of Philadelphia; Mr. John Ericsson of New York; Prof. H. D. Eddy of Cincinnati; and the Mexican Meteorological Observatory.

The death of Prof. Louis Stromeyer, at Hanover, in August, 1876, was announced by the Secretary.

The death of Mr. Robert Were Fox, at Falmouth, England, July 25, in the 88th year of his age, was announced by the Secretary.

Prof. Sadtler communicated verbally his personal observations of collections of so-called Paraffine from around the pipes and bore holes of the Oil region, and his laboratory demonstration that it was a mechanical emulsion of gas and water condensed upon the surfaces from which it is collected.

Prof. Sadtler promised soon to give the finished results of his investigations in the Laboratory of the University into the nature of the natural gases emitted by the oil wells. He has already discovered that the higher hydro-carbons of the marsh gas series are really present in these gases almost universally.

A description of the Spouting Wilcox Well, No. 1., in McKean county, by W. Charles A. Ashburner, of the Geological Survey of Pennsylvania, with a graphical representation of the time, order, and height of a series of jets from it, was read by the Secretary.

Mr. Briggs explained why and how this phenomenon of

paroxysmal ejection from a bore hole can only occur in case the upper section of the hole has a larger diameter than the lower.

The first of the series of colored geological county maps of Pennsylvania, in preparation by Mr. Julius Bien of New York, to illustrate the reports of progress of the Assistant Geologists of Pennsylvania, viz: a map of Fayette county, was exhibited by the Secretary, who said that its chief value consisted in its careful differentiation of the Coal Measures into four series, its exhibition of all the isolated patches left by erosion, and, in general terms, the completeness of its outcrop lines, carefully traced as they had been by its author, Prof. J. J. Stevenson, on foot, throughout the district. A copy of the old geological State map of 1842 (published in 1858) was exhibited to show the contrast, and the progress of our knowledge of local geology of the State, as well as to illustrate the different way in which the second survey of the State can be carried on, owing to more fortunate circumstances.

Prof. Chase placed upon the blackboard some of his results in a search (by request of Professor Draper of New York) for some harmonic series of lines in the solar spectrum. He gave the coincidences which appear in the case of the Gold lines, the Barium lines, and especially of Frauenhofer's dark lines, and concluded with an earnest protest against the assumption that such coincidences can be merely accidental.

Pending nomination No. 839 was read.

The following report was read by Mr. Price, as Chairman of the Committee on the Michaux Legacy:

"At a meeting of the Committee on the Michaux Legacy, of the Amer. Phil. Society, held September 8, 1877, present F. Fraley, Eli K. Price, Wm. M. Tilghman, and J. B. Townsend, it was

"*Resolved*, That out of the reserved interest of the Legacy, trees from Fairmount Park be planted in the grounds of the University of Pennsylvania, not to exceed in cost one hundred dollars ($100).

"*Resolved*, That it is recommended to the Park Commissioners to supply the trees for the above purpose, as far as suitable, from importations made by the Society's appropriations to the Park Commission out of the Income of the Michaux Legacy."

On motion the report was accepted and an appropriation of one hundred dollars ($100) was made to meet the expenses indicated therein.

On motion of Dr. Rushenberger it was

Resolved, That the Curators be requested to inquire into the expediency of depositing the collection of implements illustrative of the Stone Age, bequeathed to the A. P. Society by the late Mr. Franklin Peale, in care of the Academy of Natural Sciences of Philadelphia.

And the meeting was adjourned.

Stated Meeting, October 5th, 1877.

Present, 12 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters of acknowledgment were received from the Teyler Museum at Harlem (96, 98, 99); and the Glasgow Phil. Society (99).

Letters of envoy were received from the Depart. of Interior, Washington, September 27; and the Museum at Mexico, August 18, 1877.

Donations for the Library were received from the Society at Ulm; the Academy at Brussels; the Révue Politique; British Association; Geological Society, Meteorological Society, and London Nature; from the Essex Institute; Boston S. N. H.; Silliman and Dana; Cornell University; Franklin Institute; College of Pharmacy; Dep. Interior and Signal Service Office; and the Museum and Observatory in Mexico.

The death of M. U. J. J. LeVerrier, at Paris, September 23, 1877, aged 66 years, was announced.

A communication entitled: "Level Notes and Compass Courses of the Seaboard Pipe Line, from the mouth of Black Fox run, Clarion county, Pa., to Patapsco river, near Baltimore, Md. Lines run by O. Barrett, Jr., C. E. Western Division; B. F. Warren, C. E. Middle Division; J. B.

Haupt, C. E. Eastern Division; Gen. Hermann Haupt, Chief Engineer;" was received from Gen. Haupt.

In handing in this communication the Secretary explained the object of the survey, and the high value attaching to this the first accurately measured and leveled section across Pennsylvania and Maryland; the use it will be to the topographical and geological surveys of the State; and certain features both of resemblance and contrast which it presents to the long sections across the State prepared from less accurate data in 1841, and published in 1858.

Another communication on the same subject was received from Mr. O. Barrett, Jr., C. E., entitled: "A list of elevations above mean tide through the county of Indiana in Pennsylvania; from notes of survey under Gen. H. Haupt, for the Seaboard Pipe Line."

Pending nomination No. 839, and new nominations Nos. 840, 841, 842 were read.

The following Report of the Curators was read by Dr. Cresson:

"The Curators respectfully report in reference to the deposit in the Academy of Natural Sciences of the Stone-age Relics, received from Mrs. C. E. G. Peale, that they consider that for the present it will be a proper disposition of the collection. They recommend, that after proper assurance that the building of the A. N. S. is fire-proof, in accordance with the terms of the bequest, the transfer be made, subject to the usual agreement as to return upon demand. The following letter from Mr. Patterson, Executor, assures the Society that thi proposition has his concurrence, and that they shall not be put to expense for making the transfer or setting up the relics in cases.

"PHILADELPHIA, October 2, 1877.

Messrs. Tyndale and others, Curators of the A. P. S.

Gentlemen:—Referring to the Proceedings of the Society on November 19, 1875, in reference to the bequest of Stone-age Relics made by Mrs. C. E. G. Peale, I ask your further consideration and that of the Society to providing a place of deposit for the collection where it may be open to the inspection of the public.

"Mrs. Peale's bequest is conditioned on the collection being lodged in a fire-proof building; and it now lies in the building of the Philadelphia Saving Fund Society, but is boxed up so as to be unavailable for examination. This disposal of the collection, while technically in compliance with

the Will, does not carry out what I know to have been the wishes of the testatrix. I would respectfully suggest that an arrangement could probably be made with the Academy of Natural Sciences to receive the collection as a deposit by the Society. If that can be done, I would cheerfully bear the necessary expense of making the transfer and setting the relics in the cases.

Yours respectfully,

ROBERT PATTERSON,

Executor."

On motion of Dr. Cresson, it was then

Resolved, That the Curators be directed to transfer the collection of Stone-age Relics, received from Mrs. C. E. G. Peale, to the custody of the Academy of Natural Sciences, in accordance with their recommendation of this date.

Dr. Rogers made an explanation in behalf the Coal Slack Premium Committee, stating that the absence of members of Committee during the summer holidays had made a full meeting of the Committee difficult to obtain; that consequently no action had been taken by the Committee on the Society's resolution of August 17, to advertise the Premium; that, nevertheless, Mr. Briggs, one of the Committee, had given extensive publicity to the intentions of the Society through his own private correspondence and by an article in the Iron Age, which he read; and he desired therefore to know whether further advertisement would be deemed necessary.

In the course of the debate which ensued, and at one stage of which Mr. Fraley left the chair for the purpose of participating in it, Mr. Price taking the chair for the rest of the evening, Mr. Briggs offered the following resolution:

Resolved, That the following advertisement be made public, signed by the Secretaries:

"Premium for the successful utilization of Anthracite Coal Dust.

"The American Philosophical Society of Philadelphia having voted to offer a premium of $500 'for the successful utilization of anthracite coal dust, to be competed for under rules of the Society,' public notice is hereby given that applications for the premium will now be received, and that all such as may be presented within three months of the date of this advertisement will be considered as competing for the same.

"In considering the award for premium the Society will not only require that the process presented shall successfully accomplish the result, but that

the utilization shall be shown to be advantageous and profitable in the general markets for anthracite coal, and shall have become a practical substitute for what is now considered merchantable anthracite.

"Where the claim for the premium is made upon any alleged invention or discovery, the priority or originality of such invention or discovery will be investigated, and no premium will be awarded except to the first inventor or discoverer; but when the claim is founded upon the successful introduction by the adaptation of known processes the award will be made to the person or persons who shall have effected the public use primarily and extensively.

"Any person may apply for this premium by letter addressed to the American Philosophical Society, and the primary application need only state the nature of the process, or ground of claim, and the address of the applicant.

"Such application will then be referred to a Committee of the Society before whom the full statement of the facts can be made, and by whom they will be considered and reported upon for action of the Society in making the award.

Dr. Rogers moved that all after the word "Resolved" be stricken out from Mr. Brigg's resolution, and the following be substituted:

Resolved, That no advertisement shall be made until a basis be determined by the Society on which its award of premium shall be made.

Pending debate on which, both resolutions were withdrawn by the movers, and Mr. Fraley offered the following resolution, which was accepted by Mr. Briggs and Dr. Rogers as a substitute for their own respectively, and was passed:

Resolved, That the Secretaries of the Society be requested to prepare and submit to the Society at the next stated meeting a form of advertisement for applications for the premium on "Any successful process by which the Anthracite Coal-dust may be economically utilized." (See Proc. A. P. S., Vol. x. p. 278.)

And the meeting was adjourned.

Stated Meeting, October 19th, 1877.

Present, 12 members.

Vice-President, Mr. PRICE, in the Chair.

A photograph of M. Mariano Barcena was received for the Album.

Letters of acknowledgment were received from the

On the results of Surveys in 1876-7 made for the purpose of Rectifying the System of Rail Road and Oil Well Levels throughout North West Pennsylvania.

By J. F. Carll, Assistant Geologist in Charge of the Survey of the Oil Regions.

(*Read before the American Philosophical Society, May* 4, 1877.)

No attempt has heretofore been made to compare and adjust the levels of the numerous lines of Rail Roads interlacing the Oil Regions; consequently considerable misapprehension exists, not only as to the true ocean levels, but also as to the relative levels of many places frequently quoted and taken as points from which to calculate the fall of the surface and streams, or the dips of the oil rocks.

Within this district not one point of elevation has been *proven* to be correct. Harrisburg, Pittsburgh and the surface of Lake Erie are the nearest reliable points we have; and their true heights above mean ocean level have only recently been fixed through the well directed and successful efforts of Mr. Jas. T. Gardner, Geographer to the United States Geological and Geographical Survey of the Territories, under the charge of Dr. F. V. Hayden, United States Geologist.

These elevations above mean surface of the Atlantic Ocean—Harrisburg 320′, Pittsburgh 745′, and Lake Erie 573′—are now adopted; and from them we propose to carry forward the Rail Road lines of this district, to compare their intersections and junctions, and to fix and adopt certain points of elevation on which to base our geological work.

This, perhaps, should have been one of the first tasks of the Survey, but the material for it could not at that time have been immediately obtained, for even now after working towards the point for three years, much is wanting to make the adjustment as complete as could be wished.

The road most closely connected with the work of this district, is the Pittsburgh, Titusville and Buffalo Railway. It passes through the heart of the Oil Regions, along the valleys of the Allegheny River and Oil Creek from Pittsburgh to Corry and thence over the "divide" to Brockton. Unfortunately, its levels have been very unreliable; not so much, as we discover, now, from inaccuracy in the original instrumental work, as from a want of care in adjusting the datum planes of the several roads composing the present continuous line, to ocean level.

The elevation of Oil City, based on these levels has been variously given from 995′ to 1049′ above tide.* Other places along the line have varied in the same manner, but not to so great a degree.† There was also a want of agreement with the railways intersecting it, at the West Pennsylvania

* Meaning mean *high* tide at Philadelphia, Pennsylvania Rail Road datum; mean *tide* at Baltimore; mean *tide* at New York (Via Lake Erie), &c.

† Except at points like Driftwood on the Philadelphia and Erie Rail Road.

Rail Road Junction ; at Red Bank ; at Parker's ; at Oil City ; and at Corry. In 1875 the engineers in charge of the A. V. R. R. re-leveled its track from Kittanning up to South Oil City, but their work was based on the Kittanning bench-mark, the true elevation of which was in doubt. So that previous to the commencement of these examinations and our adjustment of the levels, we had not been able to secure a single elevation along the A. V. R. R. on which it seemed safe to rely.

As the shortest way out of these difficulties, and to establish some reliable base for the use of the survey, a re-leveling of the road, as far as might be necessary was resolved upon. Accordingly, early in February 1877, Mr. John H. Carll and Mr. Arthur Hale, provided with a superior rail road level and staff, proceeded to Pittsburgh to commence the work.

Every facility was afforded by the Chief Engineer of the Railway, Mr. H. Blackstone, to whom our thanks are due for these courtesies, for the examination of profiles and note books, and all the data of use secured from the office of the Rail Road Company.

Our levels were commenced at the Union Depot bench-mark and carried forward continuously to the old Kittanning bench-mark. A table comparing the results with a Railway profile, is appended. It shows a difference of only $\frac{22}{100}$ of a foot between the Railway profile elevation of the Kittanning bench-mark and our own ; and establishes the height of this bench at 809.94′ above mean surface of the Atlantic Ocean.*

From Kittanning to South Oil City there is a rise of 299.20′ according to the Rail Road levels of 1875. But in a table of elevations furnished the Smithsonian Institution by the engineer of the road shortly after its completion, the difference between the same points is given as 298′. The levels of 1875, consequently, make the elevation of South Oil City 1009′, the old levels 1008′.

From W. Pennsylvania Junction our re-leveling was carried on up the Butler Branch Rail Road, to Great Belt City. Here connection was made with our line run along the oil belt by Messrs. Hatch and Hale in 1875 and by Messrs. Chance and Hale in 1876. This last named line was then adjusted to the Pittsburgh datum, traced back to Parker's depot and found to coincide there within $\frac{4}{10}$ of a foot with the Allegheny Valley Rail Road, corrected elevation—thus showing a very reliable circuit from Allegheny Junction to Great Belt, from Great Belt to Parker's and from Parker's back to Allegheny Junction. So far the levels appear to be satisfactory.

From Parker's to Oil City, the following check was kindly furnished by Mr. D. Jones Lucas, Resident Engineer of the Union Pipe Company. Mr. Lucas ran a line of levels across the country in 1875 from Parker's depot to Oil City (Union Depot), and found the difference in elevation to be 118.9′. This added to our accepted elevation of Parker's 889′, gives 1008′ as the proper height of Oil City (U. Dep.) which is 0.45′ lower than the South Oil City Depot.

* As established by United States Coast Survey in New York Harbor.

We now have these figures, using the decimals for Union Depot, Oil City.

By levels of 1875, Kitt. bench.....809.94 + 199.20 — 0.45 = 1008.69
" Old levels " " .....809.94 + 198.00 — 0.45 = 1007.49
" Mr. Lucas, Parker's Depot.....889.4 + 118.90 = 1008.30

It seems safe therefore to accept 1008′ as the established elevation of this point.

Our levels thus adjusted to Oil City, the next step was to connect the termini of the several Railroads centering there, with the Union Depot. When this was done the following rather discouraging results appeared:

Union Depot	accepted	elevation			.....	1008′
"	"	by levels	of	O. C. & A. R. R.	.....	995′
"	"	"	"	" A. & G. W. R.	.....	1007′
"	"	"	"	" L. S. & M. S. R.	.....	1011′

The O. C. & A. R. levels appear to agree with the P. & E. and were supposed to be based on the P. R. R. datum at Philadelphia, which required an addition of 7′ to reduce it to ocean and make it conform to Lake Erie at 573′ above ocean. The A. & G. W. and L. S. & M. S. levels came in direct from Lake Erie. There was evidently some error between Oil City and the Lake if our accepted elevation of the Union Depot was correct. We endeavored to find it by connecting together the several Depots and benchmarks obtained from the railroad profiles, at Franklin, Irvineton, Corry, Union City and Erie, but did not succeed, and finally as a last resort, releveled the P. & E. R. R. from Union City to its junction with the L. S. & M. S. at Erie, and to the Lake.

To our surprise, the profile of the P. & E., which had been considered unreliable, was found to be remarkably correct, except as to ocean datum. The stations checked closely in every case, except in one or two instances where no doubt there had been an alteration of track, and the difference of elevation between Union City and the crossing at Erie as given by it and as ascertained by our levels varied only 0.08′.

By connecting the P. & E. Depot at Union City with the A. & G. W. Depot at the same place it was found that these two roads gave precisely the same fall from Cory crossing to Union, so that it was not deemed necessary to re-level that part of the P. & E. Rail Road.

From the Erie crossing above mentioned, connection was made with the L. S. & M. S. Depot at Erie, and, also, a line was run direct to the Lake. The line to the Lake confirmed the elevation given by the L. S. & M. S. R. R. for the Depot at Erie. It showed about six inches less elevation, but this is probably due to full water in the lake at this season of the year.

The P. & E. levels may therefore be considered as well tested and checked from the lake to Corry crossing, and they establish the latter point as will be seen further on at 1427′ above ocean (at New York).

When we inquire into the reason why 1416′ was given on the old P. &

E. profile as the elevation of the old Corry depot, and A. & G. W. crossing, instead of 1427 as it should be; we find that the levels of this end of the road, as far east as Warren (how much farther we do not know) were run from the Lake. They were based on lake level at 565′, the accepted elevation of the lake at the date of that Survey, and were consequently 8′ too low. In addition to this there seems to have been an error in placing the old P. & E. Lake Depot 8′ above the surface of the Lake. It should have been 11′ as the levels now show. It appears quite probable that this 3′ error in starting at the lake was discovered and corrected in some of the engineers' notes, for I have a copy of the levels from Irvineton, west, procured from the Smithsonian Institution in which the Stations are all raised 3′ above Burgin's profile. This 3′ error added to the 8′ difference between former and present accepted lake level, makes the 11′ which we are obliged to add to raise the road to its proper height above the ocean and to place it in its true horizon to meet the levels brought up from Pittsburgh.

The first elevation given on the P. & E. profile as published (crossing of the L. S. & M. S. R. R.) shows very plainly that there is an error of 11′ between that point and the Lake thus:

L. S. & M. S. crossing by P. & E. profile (VIII)				= 676
"	"	"	" L. S. & M. S. profile (XI)	= 687
"	"	"	" Carll's levels to lake	= 687

As the levels and checks above mentioned appear to establish the correctness of the P. & E. profile from the Erie crossing to Corry we see no reason to doubt its integrity as far as the same parties carried forward their line, which we are informed by one who assisted in the Survey, was as far as Warren. We therefore propose to raise all the stations between the Lake and Warren 11′.

We now find that the Union and Titusville or O. C. & A. R. R. R. (a) must be raised 13′ at Union City above the published levels to lift it to the P. & E. at that place, and 13′ also at the other end at Irvineton to make it coincide there with the P. & E. This brings Oil City up also and makes it agree (995′ + 13′ = 1008′) with our accepted elevation, as will be shown further on.

Another interesting fact is brought to light by this discussion. The levels of the O. C. & A. R. R. were run from a datum given in the field book as "Elevation of track on bridge east of Irvineton Station on P. & E. R. R. above tide water at west end of Market Street bridge at Philadelphia = 1160."

This is, no doubt, the point given by Burgin as "Irvine 1162" and it explains why (having started 2′ too low) the O. C. & A. R. R. requires to be raised 13′, while the P. & E. is only raised 11′. It also shows that the O. C. & A. R. R. datum was not the P. R. R. datum as supposed, but ocean datum, based on Lake Erie at 565′, subject to the same error of 11′ as the P. & E. with the additional 2′ made in the starting point at the bridge.

(a) The U. & T. is now a branch of the O. C. & A. R. R. R.

The two tables of the P. & E. levels (the Company's and Burgin's) given by Mr. Allen, in his R. R. levels of Pennsylvania, contain in themselves the evidences of inaccuracy. The Company's profile datum is "Mid tide Baltimore." Burgin's is P. R. R. datum on the east end and Lake Erie based on ocean on the west end (but now shown to be 11′ too low), yet both profiles give the same elevation at Corry crossing and I believe run exactly together from Corry to the lake, if they could be compared at precisely the same points. They seem both to have been made from one line of levels. Where the error in joining the line run from the east with the line run from the west may have occurred we do not know,* but certain it is that no "P. R. R. datum" or "mid tide Baltimore datum" levels have been correctly brought through to Irvineton.

Mr. Gardner in his discussion of R. R. levels to establish the surface elevation of Lake Erie, says, Lake Erie is above Harrisburg by P. & E. levels 251′; this added to the height of Harrisburg, 319.75′ = Lake Erie 570.75′. If the levels of this road were run from Harrisburg west, and from the Lake east, it is perceived at once that the P. & E. levels had nothing whatever to do with the difference of elevation between Harrisburg and the Lake. It was only the difference between 314′, the starting point at Harrisburg as given by Burgin and 565′ the starting point at Erie. The Harrisburg end was raised 5.75′ to bring it up to correct ocean level, the Lake end 8′ to bring it up to accepted lake level, consequently the line showed an error of 2.25 making Lake Erie, 570.75′ instead of 573′. Of course it was supposed that the levels were corrected throughout, but they could not have been correctly connected in fact, for we shall show that while the western end requires to be lifted 11′ the centre needs to be raised from 19′ to 23′.

We have met this same trouble in other roads in this district, where they have been run from one known, or supposed to be known, elevation to another. They agree at each end with the points given, but our cross checks lead to the suspicion that it has required some adjustment and alteration of the levels actually obtained to make them do so.

The re-leveling of the P. & E. R. R. and the corroborative circumstances above given should establish the correctness of our Union City adopted elevation of 1270′ and our Corry adopted elevation of 1427′ at the crossing of the P. & E. and A. & G. W. Railways almost beyond a question. They cannot vary more than the fraction of a foot from the figures here given. They also furnish the data from which to adjust the levels of the O. C. & A. R. and Union & Titusville Railways leading from the P. & E. to Oil City as will be seen below.

Absolute accuracy is not of course to be expected in an adjustment of this kind, where the levels of different roads are to be tied together and com-

* It seems quite probable, we think, that the error will be found between West Creek Summit near St. Mary's and Clarion Summit near Kane. In that case West Creek Summit should be raised 19′ to correspond with Emporium, and all stations between Kane and Warren 11′ to correspond with the Lake end of the line.

pared. Slight errors necessarily creep into every profile—by the change in engineers employed; and consequent mistakes in benches and level points, which often are not plainly marked or described in the notes as they should be; by local alterations of track or change in position of depots not always carefully noted; by alterations at junctions and crossings made by one road and not recorded by the other; and by clerical errors in copying and working up the notes and profiles.

In making these adjustments considerable time has been spent in the field in ascertaining the relation levels of depots, crossings, benches &c. At Pittsburgh, Allegheny City, Freeport, Parker's, Franklin, Oil City, Irvineton, Titusville, Corry, Union City, Erie City, Girard and other places, and in every case more or less variation has been found, relatively, in the points given—comparing them as they now are and as they were when originally established. These sources of error cannot now be eliminated without a careful re-leveling of the railway lines, which manifestly is an impossibility under the circumstances. It only ramains for us to make the best practical use we can of the materials at command. As we have shown that they are somewhat defective it would be folly to pretend to work out these hypsometric elevations to the decimal part of a foot. We shall not attempt it but aim only to establish the levels of some of the more important points in this district within a foot or two of the truth which is near enough for all practical purposes.

A

The first line considered will be from Pittsburgh to Lake Erie by the Allegheny Valley, Bennett's Branch, Philadelphia & Erie, and Buffalo, N. Y & Erie Railways.

			Above ocean.
Pittsburg U. Depot.		Accepted elevation	745
Red Bank Junct	106	Above Pittsburgh by A. V. profile (I)	851
" "	832	" ocean by Bennett's Branch " (IV)	
" "	19	Too low on " " " "	
Driftwood Junc.	37	Below Red bank Junct. by B. Branch profile (IV)	814
" "	795	Above ocean by P. & E. profile (Note to IV)	
" "	19	Too low on P. & E. profile	
Emporium Junc	208	Above Driftwood Junc. by P. & E. profile (Allen CCXV).	1022
" "	1003	Above ocean by P. & E. profile (do.)	
" "	1021	" " B.N.Y. & P. " (XVII)	
" "	19	Too Low on P. & E. "	
" "	1	" " B. N. Y. & P.	
Olean Crossing	414	Above Emp. Junct. by B. N. Y. & P. profile (XVII).	1436
" "	1438	Above ocean by N. Y. & Erie profile (Jersey City datum)	
" "	1435	Above ocean by B. N. Y. & P. "	
" "	2	Too high on N. Y. & Erie "	
" "	1	" low "	
Lake Erie	862	Below Olean Crossing by B. N. Y. & P. profile (XVII)	
" "	864	Below Olean Crossing by N. Y. & Erie profile (XVIII)	
" "	863	Below Olean—mean of the above levels...	573

This line it will be noted lifts all the levels from Red Bank Junction to

Emporium Junction 19 feet, and the B. N. Y. & Philadelphia levels 1′ as far as Olean. It crosses the N. Y. & Erie Railway at Olean two feet below the Erie levels, which were run from tide at Jersey City and would reach the Lake one foot too high if carried down by the B. N. Y. & Philadelphia levels, which gives 862′ fall. But we find that the N. Y. & Erie levels give 864′ fall so that a mean between the two, 863′ subtracted from 1436′ = 573′ the precise elevation as accepted for Lake Erie. The B. N. Y. & Philadelphia levels are said to have been run from the water of Buffalo Creek some distance from the lake and may therefore be presumed to be based on a higher point than lake level.

Variations of from one to three feet will be found between different lines at nearly every point we are attempting to compare. As we are only rising even feet in making this adjustment, a disagreement of one foot may sometimes occur in this way between two roads where there would really be but a very slight difference if the decimals were accurately taken into account.

B.

Pittsburgh to Lake Erie by the Allegheny Valley, Oil Creek, and Allegheny River, Union and Titusville and Philadelphia and Erie Railways.

			Above ocean.
Pittsburgh		Accepted elevation	745
Oil City U. Depot	263	Above Pittsburgh by A. Valley profile (I)	1008
" "	995	Above ocean by O. C. & A. R. profile (VI)	
" "	1007	Above ocean by A. & G. W. profile (X)	
" "	1011	" " " L. S. & M. S. " (XII)	
" "	18	Too low on O. C. & A. R. profile	
" "	1	" " A. & G. W. "	
" "	3	Too high on L. S. & M. S. "	
Titusville	186	Above Oil City by O. C. & A. R. profile (VI)	1194
"	1181	Above ocean by O. C. & A. R. profile (VI)	
"	1181	Above ocean by U. & T. profile (VII)	
"	13	Too low on O. C. & A. R. "	
"	13	" " U. & T. "	
Union City P. & E. Depot		Accepted elevation established by levels from the lake	1270
" " "	177	Above Titusville by U. & T. profile (VII)	(1271)
" " "	1258	Above ocean by U. & T. profile (VII)	
" " "	1259	" " P. & E. " (VIII)	
" " "	12	Too low on U. & T. "	
" " "	11	" " P. & E. "	
Erie City			
L. S. & M. S. & P. & E. Cross'g.	583	Below Union City by P. & E. profile (VIII)	687
" " " "	583	Below Union City by levels run by J. H. Carll	687
" " " "	676	Above ocean by P. & E. profile (VIII)	
" " " "	11	Too low on " "	
Erie City			
L. S. & M. S. Depot	0.72	Below Erie Crossing (Carll's levels)	686
" "		Above ocean by L. S. & M. S. profile (XI)	686
" "	113	Above lake by L. S. & M. S. profile (XI)	
" "	113	" " " Carll's levels	
Lake Erie		As above 686–113	573

This determination shows a very satisfactory line of levels from Pitts-

burgh to the Lake by raising the O. C. & A. R. and Union & Titusville Railways 13 feet and the P. & E. Railway 11 feet and by throwing off all the decimals on the Allegheny slope and making the most of them on the Lake slope. But even by doing this there is still an error of one foot to be accounted for at Union City which is referred to more fully in remarks following determination C.

Mr. Gardner in summing up his conclusions on the elevation of Pittsburgh says he is inclined to accept 746 in preference to 745 for the elevation of the Union Depot. But the levels of the Railroads leading to the Lake through this district conform better to the height we have adopted, 745, and might even seem to suggest a lower level for Pittsburgh.

C.

Oil City to Lake Erie, by the Oil Creek and Allegheny River Railway to Irvineton and the P. & E. Railway from Irvineton to the Lake—using Burgin's profile of the P. & E. Railway.

			Above ocean.
Oil City		Accepted elevation	1008
Irvineton Bridge	165	Above Oil City by O. C. & A. R. profile (VI)	1173
" "	1162	" ocean by P. & E. " (VIII)	
" "	1160	" " " O. C. & A. R. " (VI)	
" "	11	Too low on P. & E. "	
" "	13	" " O. C. & A. R. "	
Corry Crossing			
A. & G. W. & P. & E.	254	Above Irvineton by P. & E. profile (VIII)	1427
" "	1416	" ocean " " "	
" "	1429	" " " A. & G. W. " (IX)	
" "	1418	" " " O. C. & A. R. " (VI)	
" "	11	Too low on P. & E. "	
" "	9	" " O. C. & A. R. "	
" "	2	Too high on A. & G. W. "	
A. & G. W. Depot Union City	128	Below Corry by A. & G. W. profile (IX)	1299
" "	1301	Above ocean " " " "	
" "	2	Too high on " "	
P. & E. Depot			
Union City	29.22	Below A. & W. Depot, Union City (Carll)	1270
" "	157	" Corry crossing by P. & E. profile (VIII)	1270
" "	1259	Above ocean " " "	
" "	11	Too low on " " "	
L. S. & M. S. & P. & E. Erie Crossing.	583	Below Union City by P. & E. profile (VIII)	687
" "	583	" " " " Carll's levels	687
" "	114	Above Lake Erie by L. S. & M. S. profile & Carll (XI)	687
" "	670	Above ocean by P. & E. profile	
" "	11	Two low on " "	
Lake Erie	114	Below P. & E. & L. S. & M. S. crossing as above.	573

The levels of the Dunkirk Allegheny Valley and Pittsburgh R. R. touching the P. & E. at Irvineton, are so widely astray and evidently unreliable as heretofore published that we can make no use of them in this connection to reach the Lake. A trip to Dunkirk expressly for the purpose of examining the profiles with a view of including the levels of the road in this discussion resulted unsuccessfully, for the want of a permit from headquarters in New York and we are obliged to omit them altogether.

So too, unfortunately with the Buffalo Corry & Pittsburgh Railway

crossing the P. & E. at Corry, which would have given another link to the Lake at Brocton. The published levels are so vague and uncertain that we must omit them also. Mr. Ashmead kindly permitted and assisted in a thorough search among the papers in his office at Oil City, but no profile or connected notes of the levels could be found.

If our accepted elevations of Irvineton, Corry, and Union City are correct, and we have every reason to believe that they are, it appears quite evident that there must be some mistake in the levels of the O. C. & A. R. and U. & T. Railways, otherwise they would agree with our accepted elevations if raised uniformly 13′ at all points, instead of 13′ at Irvineton, 9′ at Corry and 12′ at Union City. They start as we have shown at an elevation of 1160′ at Irvineton, which represents 1162′ on the P. & E. profile, and running around by Oil City and Titusville reach Union City at 1257′ which should represent 1259′ on the P. & E. profile if all the levels were harmonious. From the published tables it would be inferred that the P. & E. Depot in the U. & T. tables was the same as the P. & E. depot in the P. & E. tables; but the U. & T. profile shows that the point 1257′ was the junction with the P. & E. and this junction is 1.39′ lower than the depot. There is therefore a disagreement of one foot or more between the two lines of levels from Irvineton to Union City, the P. & E. being about 34 miles in length and the O. C. & A. R. and U. & T. about 92 miles. This is not sufficient to cast doubt upon the main line of levels and we therefore accept them as correct as far as Tryonville Junction, presuming that the error lies somewhere quite near Union City, for we find our levels there between the crossings and Depots to differ quite materially from those given by the U. & T. profile as will be seen by reference to Union City levels.

We now have these three points apparently well established.

Tryonville Junction.....1320′
Corry.....1427′
Union City.....1270′
Tryonville Junction is 111′ below Corry by O. C. & A. R. (VI).
" " 49′ above Union City by U. & T. (VII).

Then calculating the elevation of Tryonville J. from Corry and Union City we have:

Tryonville by O. C. & A. R. levels $1427 - 111 = 1316$
" by U. & T. " $1270 + 49 = 1319$

The relative elevations of Corry and Union City are well assured by the exact agreement of the P. & E. and A. & G. W. levels between those places, and we therefore can only conclude that there is an error of one foot to be accounted for on the U. & T. profile between Tryonville Junct. and Union City, and an error of 4′ on the O. C. & A. R. profile between Tryonville and Corry which we have been unable to place and must, therefore, leave for future adjustment.

D

Oil City to Ashtabula by Franklin Branch of Lake Shore and Michigan Southern Railway.

			Above ocean.
Oil City,		Accepted elevation	1008
Stoneboro'	160	Above Oil City by L. S. & M. S. profile (XII)	1168
"	1171	" ocean " " " (XII)	
"	1171	" " by N. C. & F. " (XIV)	
"	3	Too high on L. S. & M. S. "	
"	3	" N. C. & F. "	
Salem Crossing.	184	Below Stoneboro' by L. S. & M. S. profile (XII)	984
" "	987	Above ocean " " " (XII)	
" "	982	" " by A. & G. W. " (IX)	
" "	3	Too high on L. S. & M. S. "	
" "	2	" low " A. & G W. "	
Jamestown	3	Above Salem Crossing by L. S. & M. S. profile (XII)	987
"	990	" ocean " " " (XII)	
"	979	" " E. & P. " (XIII)	
"	3	Too high on L. S. & M. S. "	
"	8	" low " E. & P. " (a)	
Ashtabula	342	Below Jamestown by L. S. & M. S. profile (XII)	645
"	648	Above ocean " " " "	
"	3	Too high on " " " (b)	

(a) The two depots here are not on precisely the same level, but there certainly cannot be 11′ difference in their elevations. The E. & P. appears to be wrong wherever we check it.

(b) These levels, according to profile, run into Ashtabula at the proper elevation (74.52) to agree with the levels of the main line which are accepted as correct. But it is hard to explain why the Franklin Branch overruns the A. & G. W. at Salem Crossing, at Franklin, at Reno, and at Oil City, while the same levels of the L. S. & M. S., taken at Erie Crossing and Carried to Union City by the P. & E. Railway, run under the A. & G. W. at that place. The P. & E. levels from Erie to Union City were re-run but no error could be discovered there. We have no ground for charging the whole mistake to the A. & G. W., for their levels, as will be seen in another place, bear every evidence of more than ordinary precision from Salamanca to Dayton. It would appear as if the Franklin Branch of the L. S. & M. S. had been started from a higher point than that given on the main line as 74.52. But this, of course, is an inference only and may be entirely wrong.

E

From Pittsburgh to Stoneboro' by Pittsburgh, Fort Wayne and Chicago to Homewood, New Castle and Beaver Valley to New Castle and Franklin to Stoneboro'.

			Above ocean.
Pittsburgh.		Accepted elevation	745
Homewood.	204	Above Pittsburgh by P. F. W. & C. profile (XVI)	949
New Castle.	147	Below Homewood by N. C. & B. V. " (XV)	802
" "	809	Above ocean by E. & P. " (XIII) (a)	
" "	7	Too high on " "	
Stoneboro'.	368	Above N. Castle by N. C. & F. profile (XIV)	1170
"	160	" O. City by L. S. & M. S. profile (XII) accepted (b)	1168
"	1171	" ocean " " " "	
"	1171	" " N. C. & F. " (XIV)	
"	2	Too high by levels brought from Pittsburgh	
"	3	" on L. S. & M. S. profile	
"	3	" " N. C. & F. "	

(a) It is supposed that the elevation here given by the E. & P. refers to a point somewhat higher than the present Depot.

(b) We prefer to accept 1168′ as the elevation of Stoneboro' instead of 1170′ or 1171′ for several reasons. From Pittsburgh to Oil City by the line just followed we find a rise of 265′, while from Pittsburgh direct to Oil City by the A. Valley Railway levels well tested we have a rise of 263′. There is an error of 2′ somewhere in the circuit. The L. S. & M. S. levels are too high at Oil City when compared with the A V., the O. C. & A. R. and the A. & G. W.; they are too high again at Franklin, compared with the A. V. and A. & G. W.; too high at Salem Crossing, compared with the A. & G. W.; and too high at Jamestown, compared with the E. & P. We are not certain that the connecting link between N. Castle and Stoneboro' shows precisely the difference in elevation between the Depot of the N. C. & B. V. at N. Castle and the Depot of the L. S. & M. S. at Stoneboro. There might easily be a difference of two feet between the Depots of the N. C. & F. and those of the other roads named. Our accepted level at Oil City appears to be a mean between the highest and lowest levels given wherever a check can be secured, and it therefore seems safe to adhere to it.

F

Review of the levels of the Atlantic and Great Western Railway.

			Above ocean.
Salamanca . .	1393	Above ocean by A. & G. W. profile (IX)	
		Point given as centre of Hemlock st.	
" . .	1384	Above ocean by N. Y. & Erie profile (XVIII)	
		Supposed to be the old Depot	
Present Depot.	1.3	Lower than Hemlock St. (Carll)	
Old Depot. . .	14.2	" " " " "	
Present Depot.	1392	Above ocean by A. & G. W. levels (1393–1)	
" "	1397	" " N. Y. & Erie " (1384–13)	
" "		Accepted elevation.	1393

The N. Y. & Erie, as before stated, reaches the Lake 2′ too high, so that there appears to be but 3′ disagreement between the levels of the A & G. W. and the N. Y. and Erie, if we have taken our points correctly, and 1393′ will be a fair mean between the two for the present depot.

Levant, Accepted elevation as given by A. & G. W. (IX) 1267

The D. A. V. & P. Ry. coming up from the lake at Dunkirk crosses the A. & G. W. here. The elevation given by it is 1262 (Allen CCCVI), but it does not appear to be reliable.

Corry, A. & G. W. 2′ too high as shown in C.

Union City, A. & G. W. 2′ too high as shown in C.

Salem Crossing, A. & G. W. 2′ too low as shown in D.

			Above ocean.
Clarkesville Crossing	46	Below Salem Crossing (D) = 984–46.	938
" "	936	Above ocean by A. & G. W. profile (IX)	
" "	930	" " E. & P. " (XIII) . . .	
" "	2	Too low on A. & G. W. " . . .	
" "	8	" " E. & P. " . . .	

At Jamestown the E. & P. was 8′ too low (D) by our accepted eleva-

tion and 11′ too low by L. S. & M. S. levels, and here we find it 8′ too low by our adjustment, and 6′ if the A. & G. W. is correct—while at N. Castle (E) it is 7′ too high. In the first and last places the difference may be in a measure due to a want of unity in the points given by the several roads, but until we have more positive information on these points the E. & P. levels must be regarded as very unreliable.

Further Checks on the A. & G. W. Railway, in Ohio:

			Above ocean.
Ravenna Cross'g.	522	Above Lake Erie by A. & G. W. profile (See Ohio. Geological Report, Vol. I, p. 667)	1095
" "	519	Above Lake Erie by Cleveland & Pittsburgh profile (Authority J. Linton, Chief Engineer)	1092
	3	Disagreement.	
Newburg Cross'g.	175	Above Lake Erie by A. & G. W. profile (IX)	748
" "	174	" " " C. & P. " (Linton)	747
	1	Disagreement.	
Gallion	596	Above Lake Erie by A. & G. W. profile (O. R. I, p. 667)	1169
"	595	" " " C. C. C. & I. " (O. R. I, p. 668)	1168
	1	Disagreement.	
Urbana	454	Above Lake Erie by A. & G. W. profile (O. R. I, p. 667)	1027
"	458	" " " S. D. & C. " (O. R. I, p. 671)	1031
	4	Disagreement, relative levels of depots unknown	
Dayton	179	Above Lake Erie by A. & G. W. profile (O. R. I, p. 667)	752
"	180	" " " D. & M. " (O. R. I, p. 671)	753
	1	Disagreement.	

The Dayton & Michigan Railroad check is used by Mr. Gardner (page 644) and accepted as reliable.

G.

East end of the Philadelphia and Erie Railway, compared with the Northern Central.

			Above ocean.
P. R. R. Datum.			0.913
Harrisburg	313	Above P. R. R. datum by P. R. R. profile (Allen I)	320
Bridgeport Cros'g	29	Above Harrisburg by P. R. R. profile (Allen I)	349
" "	30.25	" " by N. C. profile (Gardner, pp. 635)	350
Sunbury		Above Ocean by N. C. profile (Allen CC)	444
"	428	" " P. & E. " (Allen CCXV)	
"	430	" " Burgin's " " " "	
	16	Too low on P. & E. profile	
	14	" " Burgin's "	
W'msport Junct.		Above Ocean by N. C. profile (Allen CCXVII)	540
" "	516	" " P. & E. " (Allen CCXV)	
" "	24	Too low on P. & E. profile	
" Depot	5.50	Below Junction by P. & E. profile (Allen CCXV)	
		On Northern Central bases (540-6)	534
" "	510	Above ocean by P. & E. profile (Allen CCXV)	
" "	513	" " by Burgin's " " "	
" "	24	Too low on P. & E. profile	
" "	21	" " Burgin's "	
Elmira		By N. C. profile (Allen CCXVII)	865
"		By N. Y. & E. profile (Allen CLXII)	863

This last check makes the Northern Central levels appear good. The levels of the N. Y. and Erie Railway have been brought up from Jersey City, about 273 miles, and those of the Northern Central from Baltimore, 256 miles showing a disagreement of only two feet at Elmira. It seems quite safe, therefore to assume that the P. & E. elevations of Sunbury and Williamsport are altogether too low, as they have likewise been shown to be at Driftwood, Emporium, Irvineton, Corry, Union City and Erie.

CONTRIBUTIONS FROM THE LABORATORY OF THE UNIVERSITY OF PENNSYLVANIA.

No. IX.

Upon some new Chlorine Derivatives from Toluol.

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(*Read before the American Philosophical Society, May* 4, 1877.)

The first of these derivatives which it is my intention to describe in the following lines was obtained by me some time ago, and also a description of it published (Inaugural Dissertation, Göttingen, 1876), but as it is intimately connected with the subsequent work a brief description of its production and properties may probably not be amiss.

PRODUCTION OF TOLUOLTRICHLORIDE OR BENZYLTRICHLORIDE.

This was obtained in the usual manner, viz.: By the introduction of a calculated amount of dry chlorine into boiling Toluol. The liquid boiling at 218° C. was collected and treated as follows:

FORMATION OF C_{21} Cl_{26}.

The pure Benzyltrichloride was placed in a large flask and dried chlorine gas conducted into the liquid until it was no longer absorbed and the vacant space also filled with it, when the flask was tightly corked and exposed to the action of the sun-light. After standing a few days the green color of the chlorine had disappeared. The flask was again filled with the gas and this operation repeated, until the chlorine was apparently no longer absorbed. The flask was now set in a rather cool place and allowed to remain there for some time. After standing several months I noticed that crystals had separated from the liquid. These were immediately brought upon a filter, washed thoroughly with water and then pressed between filter paper to remove any Benzyltrichloride that may have adhered to the crystal mass. After drying the compound by exposure to the air, it was pulverized and dissolved in chloroform, from which solution it crystallized in fine, colorless crystals, which after repeated re-crystallization fused at 152°–153° C.

Properties.—The compound possesses an odor very similar to that of camphor, is insoluble in water and alcohol, but readily soluble in chloroform. It is volatile without decomposition. My attempts to affect the introduction of the NO_2 group were unsuccessful. Even with the aid of heat nitric acid is without any action.

If the compound is allowed to crystallize slowly from a chloroform solution, crystals may be obtained half an inch long and one-fourth of an inch broad. These have prism and dome faces.

I never succeeded in obtaining the compound during summer, very probably because the Benzyltrichloride held it in solution.

Numerous analyses made of the compound lead to the following formula: C_{21} Cl_{26} = (C_6 Cl_6 C Cl_3). (C_6 Cl_5 C Cl_3). (C_6 Cl_6 C Cl_3).

We have here, then, a compound in which three benzol groups have very probably combined, containing only carbon and chlorine.

Analyses.

Chlorine Determinations.

I. The compound was dried over sulphuric acid and burned with oxide of lime, and the calcium chloride which was produced dissolved in nitric acid and the chlorine precipitated with silver nitrate.

0.2181 Grm. substance gave .6928 Grm. silver chloride, corresponding to 78.53% chlorine.

II. .1035 Grm. substance gave .329 Grm. silver chloride = 78.58% chlorine.

III. 0.0868 Grm. substance gave .2765 Grm. AgCl = 78.57 % chlorine.

IV. Finally, I fused a portion of the compound on a watch glass and then heated it with oxide of lime.

.0893 Grm. sub. gave .2843 Grm. silver chloride = 78.75% chlorine.

Carbon Determinations.

I. .3629 Grm. substance dried at 75°C. and then burned with coarse lead chromate, yielded .0780 Grm. CO_2 = 21.41% carbon.

Not any water was noticed in the calcium chloride tube and its weight had not increased.

II. .2513 Grm. dried substance, burnt with lead chromate gave .0536 Grm. CO_2 = 21.33% carbon.

III. .1677 Grm. well dried substance gave .0361 Grm. CO_2 = 21.51% carbon.

Several more combustions were made with about the same result. In no instance did the found percentage of water exceed 0.40%. This amount of moisture could have readily collected during the filling of the combustion tube.

Results.

Calculated.	Found.
C_{21} = 252 = 21.44%	21.41 — 21.33 — 21.51
Cl_{26} = 923 = 78.56%	78.57 — 78.58 — 78.53 — 78.75.

Action of Zinc and Sulphuric Acid upon C_{21} Cl_{26}.

About five grammes of the preceding compound were pulverized and dissolved in a mixture of alcohol and chloroform, and zinc and sulphuric acid added to this solution. The liberation of hydrogen gas was rather slow and to hasten it the flask containing the mixture was placed on a sand-bath, where a constant temperature of 60°C. was maintained for ten weeks, during which period there was a constant and brisk disengagement of hydrogen gas. The flask was now placed upon a water-bath and the alcohol and chloroform removed by distillation. An impure oil remained as a residue and upon cooling solidified and was then taken from the flask and dissolved in a mixture of chloroform and alcohol. After removing the impurities by filtration, the solution was strongly evaporated and when cool the compound separated partly as an oil and partly in colorless tablets.

After pouring off the supernatant liquid the crystalline mass was pressed well between filter paper and then dissolved in alcohol. From this solution the compound crystallized in beautiful, colorless, quadratic plates, which after several recrystallizations fused at 102° C.

Properties. If a crystal is fused upon a piece of glass it will remain in a plastic condition for hours and stirring it with the point of a knife blade will not cause solidification. One crystal which I fused required twelve hours before becoming solid. The fusing point of this solidified mass was the same as that of the crystals, 102° C.

The compound may be volatilized without suffering decomposition. When pure it possesses a very peculiar, aromatic odor, somewhat like that of the preceding compound, being only more piercing.

The compound is perfectly insoluble in water, but very readily soluble in chloroform. The best solvent I found to be alcohol, in which, when warm, it is exceedingly soluble.

The following analyses were made :

Chlorine Determination.

0.4180 Grm. substance dried over calcium chloride and burned with oxide of lime gave 1.3146 Grm. silver chloride = .3252 Grm. chlorine = 77.79% chlorine.

Carbon Determination.

.3812 Grm. air dried substance burned with lead chromate, gave 21.69% carbon and 1.00% hydrogen.

If we suppose that only one hydrogen atom has replaced chlorine, the following numbers would be required :

Calculated.	Found.
C_{21} = 22.09%	21.69%
Cl_{25} = 77.81%	77.79%
H = 0.09%	1.0%

The formula would, therefore, be $C_{21}\,Cl_{25}\,H$. That the replacement would be so very limited, one would naturally suppose if he considered the presence of such a large number of negative chlorine atoms.

ACTION OF SODIUM AMALGAM UPON $C_{21}\,Cl_{25}\,H$.

The substance was finally divided and dissolved in an excess of alcohol, and sodium amalgam added to the solution. The liberation of hydrogen gas was at first very violent, finally, however, the application of heat upon a sand bath was necessary to render the disengagement continuous. After allowing the action to continue three or four days, I interrupted it and proceeded to examine the contents of the flask.

The alcohol was distilled off, and as the liquid gradually diminished in volume, drops of oil separated from it. Only a small quantity of the oil could be obtained, and after being purified, was too small to employ in an analysis, expected to afford some clue to the composition of the compound. Intense cold would not render this oil solid.

Action of Sodium Amalgam upon $C_{21}Cl_{36}$.

Ten grammes of the substance were reduced to a powder, placed in a small flask, and alcohol then poured in, and the whole heated upon a sand bath for four weeks. At the expiration of this time the alcoholic solution was poured off from the metallic mercury that had collected upon the bottom of the flask, and water and hydrochloric acid added to the solution to dilute it and neutralize any sodium carbonate that may have formed.

Upon adding the water I noticed the appearance of oil globules, which swam upon the surface of the liquid.

The solution was placed in a suitable vessel and subjected to distillation upon a water bath. In the receiver a rather large quantity of oil collected. In the flask, upon examination, I found merely sodium chloride.

The further addition of water to the liquid in the receiver rendered it cloudy, and it was again distilled, but this time over a free flame. The alcohol, of course, first passed over, and the addition of water to it produced no cloudiness.

The oil was carried over with the steam and collected to one large globule on the bottom of the receiver.

Soon after all the oil had passed over, I noticed the liquid carried over small shining needles. The receiver was immediately changed and the distillation continued. Only a small quantity of this crystallized compound was caught. It was exceedingly soluble. It was extracted from its aqueous solution with ether and the latter allowed to evaporate. The residue consisted of fine colorless needles, possessing a rather sharp odor. The compound fused at about 127° C. With barium carbonate it gave a salt crystallizing in white needles. Scarcity of material prevented its analysis.

To extract the oil from the aqueous solution ether was added, and the two liquids separated with a separatory funnel. After the evaporation of the ether, the oil was treated with calcium chloride, to remove any adherent moisture and afterwards dried over sulphuric acid.

Properties. The oil is perfectly clear. Insoluble in water, but soluble in ether. It is with difficulty volatilized.

The following analyses were made :

Carbon Determination.

.1132 Grm. of the oil were placed in a small bulb tube and burned with lead chromate, yielding .1603 Grm. CO_2 = .043% Carbon = 38.60% : further, .0500 water = .0056 H = 4.94% H.

Upon examining the bulb tube after the combustion, a small quantity of undecomposed carbon was noticed.

Chlorine Determination.

.0463 Grm. oil ignited with oxide of lime gave .0980 Grm. silver chloride — 52.33 % chlorine.

Result.

C = 38.60%
Cl = 52.33%
H = 4.94%

Synopsis of the Cold Blooded Vertebrata, procured by Prof. James Orton during his Exploration of Peru in 1876–77.

By E. D. Cope.

(*Read before the American Philosophical Society May* 4, 1877.)

REPTILIA.

Ophidia.

1. Bothrops pictus Tsch. Jan. Elenco Sistematico, p. 126. *Lachesis pictus*, Tschudi Fauna Peruana, p. 61, Tab. X.

Nos. 11, 14, 15, 17, 19, from Chimbote Valley, Lat. 9° S., altitude from 0 to 2000 feet.

A very distinct species, well figured by Tschudi. In five specimens the fossa is bounded in front by the second superior labial plate, as described by Jan; in one other the fossa is surrounded by small scutella.

2. Elaps circinalis Dum. Bibr. VII, p. 1210. Cope, Journal Academy Nat. Sciences, 1865, p. 182.

No. 45, Pacasmayo.

3. Elaps tschudii Jan. Revue et Magazine de Zoölogie, 1859, Prodrome d'une Iconographie, etc., p. 13.

No. 18, Chimbote Valley.

4. Oxyrrhopus fitzingerii Tschudi, Fauna Peruana Reptilia p. 56. Tab.

No. 21, Chimbote Valley.

5. Oxyrrhopus clelia Dandin. Dum. Bibron VII p. 1007.

6. Sibon annulatum Linn. *Dipsas* Dum. Bibr. VII, p. 1141. *Leptodira* Günther.

Nos. 23–25, Chimbote Valley.

7. Tachymenis peruviana Wiegmann "1834" (fide Peters); Archiv. für Naturgesch. 1845, 165.

No 72, from Cuzco; elevation 11000 feet.

This species is probably distinct from the *T. chilensis* Schleg. This conclusion is derived from an examination of Wiegmann's type in the Museum of the University of Berlin, and it is sustained by the present specimen from Cuzco. Its characters are: one preocular, eight superior labials, loreal higher than long, superior surfaces of the body and tail with four series of dark spots. The characters of the *T. chilensis* are: two or three preoculars, seven superior labials, length of the loreal equaling or exceeding the height, superior surfaces with four longitudinal brown bands.

8. Dryophylax vitellinus sp. nov.

Form moderately slender, head oval, narrowed to the rather depressed muzzle. Scales smooth, in nineteen longitudinal rows, with single apical fossæ. Eight superior labials, fourth and fifth entering the orbit. Ros-

ral small, as high as wide, just visible from above. Nasals depressed, loreal a little longer than high ; oculars 1–2, the anterior impressed, nearly reaching the frontal. Temporals 1–1–2. Internasals longer than wide ; prefrontals subquadrate. Frontal long and narrow, not angulate posteriorly ; parietals notched behind, short, their common suture a little more than half the length of the frontal. Ten inferior labials, six of which are in contact with the geneials, of which the posterior pair is a little longer than the anterior. Gastrosteges 202 ; anal double ; urosteges 93.

Color yellow, strongly tinged with brown above, and with orange on the labial plates and lower surfaces.

No. 3, from Pacasmayo.

This beautiful species presents a new type of color for the genus.

9. DRYOPHYLAX ELEGANS Tsch. *Lygophis elegans* Tsch., Fauna Peruana, p. 53, Pl. VI. *Lygophis pœcilostomus* Cope, Journ. Acad. Phila. 1875, 180.

This species was described from a young individual. Examination of several adult specimens from Prof. Orton's collection shows that the last maxillary tooth is grooved, though not deeply, and that the scales have a single apical fossa. The coloration is more striking in the adult than in the young, and is quite elegant. The ground is a light yellowish gray, and there are two rows of bright rufous darker edged spots on the back. These spots are either confluent transversely, forming a single row of broad spots, or alternating, so as to form a zigzag band. The latter condition prevails on the posterior part of the body, and the band becomes regular on the entire middle line of the tail. There are three longitudinal dark gray lines on each side, one on the middles of each of the first two rows of scales, and one on the ends of the gastrosteges. These become more or less fused on the tail, forming a single lateral band. A broad brown band from the muzzle through the eye to the first dorsal spot. Lips, gular region, and anterior gastrosteges, brown speckled ; a longitudinal median nuchal band. Frontal plate dusky, with a median longitudinal light band. Length of the longest specimem M. .901 ; tail .280.

Nos. 12, 16, 26, 27, Chimbote Valley.

This species is the type of the genus *Lygophis* Fitz. where first characterized ; *i. e.* in the Fauna Peruana. It must therefore be regarded as a synonyme of *Dryophylax* Wagl. The genus to which I have given the name *Lygophis* (Proceed. Acad. Phila. 1862, p. 75, type *L. lineatus*) may then be called *Aporophis*.

10. DRYIOPHIS ACUMINATA Wied.; *Dryinus æneus*, Wagl. Dum. Bibr. VII, 819.

No. 10. Chimbote Valley.

11. DRYMOBIUS HEATHII Cope. Journ. Acad. Philada. 1875. p. 179.

This species is nearly allied to the *D. reticulatus* (*Herpetodyas*), Peters, Monatsberichte, Berlin, 1863, 285. I add to my previous description that in a large specimen, the interocular space is only .001 wider than the length

of the muzzle ; and that the brown band through the eye becomes obsolete. Length M. 1.150 ; tail .346.

The American species of *Drymobius* (Cope, Proc. Acad. Phila., 1860. 560) are the following : *D. margaritiferus*, Schl.; *D. reticulatus*, Pet.; *D. heathii*, Cope ; *D. rappii*, Gthr.; *D. occipitalis*, Gthr.; *D. pulchriceps*, Cope ; *D. dichrous*, Pet.; *D. boddaertii*, Seetz ; *D. melanolomus*, Cope ; *D. biserialis*, Gthr.; *D. bilineatus*, Jan.; *D. pulcherrimus*, Cope.

12. Boa ortonii, Cope, sp. nov.

This species is intermediate in character between the *Boa constrictor* and the *B. imperator*. It has the stout proportions of both species, while the squamation of the head is like that of the former, and that of the body resembles that of the latter. There are no large scuta on the loreal or orbital regions, and the scales of the head generally are characterized by their small size. The characters of the species are best brought out in a comparative table, which I give :

Sect. I. 89–95 rows of scales on the body.

Orbital ring not in contact with labials , gastrosteges 234 –40 ; urosteges 49–56.....*B. constrictor.*

Sect. II. 55–69 rows of scales.

a Orbital series separated from labials by a row of scales; No large loral plate ; form stout ; g. 252, u. 53 ; labials 19 ; orbital ring composed of 19 scales ; 64 rows on body.....*B. ortonii.*

aa Orbital ring reaching labials.

No large loral plate ; stout ; u. 56 ; 57–62 rows on body ; orbitals 13–17.....*B. imperator.*

A loral plate as large as the orbit ; proportions as in the last.....*B. eques.*

No large loral plate ; form elongate ; g. 272 ; u. 69.....*B. diviniloqua.*

With the typical specimen I associate one from Greytown, Nicaragua, which agrees with it in the generally smaller size of the scales of the head and body than is found in the *B. imperator*, the usual Mexican species. It has 69 rows of scales ; 21 labials and 17 scales in the orbital ring ; gastrosteges 242.

No. 1 from Chilete, near Pacasmayo, 3000 feet above the sea. This species is dedicated to Professor James Orton, whose explorations of the western regions of South America have yielded such abundant results.

13. Stenostoma albifrons Wagler ; var. *tessellatum*, Tsch. Fauna Peruana, p. 46.

As Jan remarks, this forms appears to be but a color variety of the *S. albifrons*.

No. 28, Chimbote Valley.

Lacertilia.

14. Proctotretus multiformis Cope, Journ. Acad. Phila. 1875. p. 173.

No. 98 ; from La Raia or the divide which separates the waters of the Ucayali and those of Lake Titicaca ; altitude 14,000 feet.

15. PROCTOTRETUS FITZINGERII Dum. Bibr. IV, p. 286.

No, 138, from Juliaca, Peru; altitude 12,550 feet. In this lizard the lateral scales are relatively smaller and smoother than in the *P. multiformis*.

16. MICROLOPHUS INGUINALIS Cope, Journ. Acad. Phila. 1875. p. 172.

Nos. 33–34, Chimbote Valley. 2000 feet.

17. MICROLOPHUS PERUVIANUS Sess. *M. lessonii*, Dum. Bibr. IV, p. 336.

Nos. 31–36, Chimbote Valley. 2000 feet.

18. PHYLLODACTYLUS NIGROFASCIATUS sp. nov.

The existence of a fourth species of this genus in Western Peru points to this region as its centre of distribution. The present one belongs to the group in which the large dermal tubercles are not prominent nor angulate, nor arranged in regular longitudinal rows. They are round, and very distinct from the small round scales between them, and not almost assimilated to them as in the *P. inæqualis* Cope. There are eight superior labials to below the pupil of the eye. The mental scutum is very large, and urceolate; it has two lateral, and a short posterior median facet, each one corresponding to a scutum. The anterior of these is the first labial, which is about twice as large as the scutum that follows it. Behind these is a transverse row of five subround scales, of which the median is in contact with the mental. The next row embraces eight, arranged in an undulating manner. The scales diminish but slowly to the size of the gulars.

The toes are slender as in the *T. microphyllus* Cope, but the expansions are large, as in the *T. inæqualis*. When the limbs are appressed to the side, the elbow reaches the base of the toes in this species, but only to their tips in the *T. inæqualis;* the length of the toes in *T. microphyllus* is intermediate.

The ground color is very light, brilliantly white on the inferior surfaces. Between the axilla and groin the back is crossed above by six narrow black cross-bands. These bifurcate or break up on the sides; the axillar band breaks up on the back, and two anterior to it are represented by spots. A broad dark band passes from the nostril through the eye and breaks up on the sides of the neck. Limbs indistinctly cross-barred.

	M.
Length to meatus auditorius	.013
" " axilla	.020
" " groin	039
" " vent	.043
Width at meatus auditorius	.007
Length of fore limb	.014
" " " foot	.004
" " hind limb	.021
" " " foot	.0065

The very different arrangement of the infralabial scales and the small

digital expansions with other characters of the *P. microphyllus** render comparisons with it unnecessary. From the nearer *P. inæqualis*† it differs primarily in three features: (1) the greater relative size of the tubercles; (2) the differently arranged infralabials, and (3) in the longer digits.

No. 35, Chimbote Valley. 2000 feet.

19. PHYLLODACTYLUS REISSII Peters Monateber. Berl. Academy, 1862, 626.

No. 140, from Pacasmayo.

BATRACHIA.

ANURA.

20. NOTOTREMA MARSUPIATUM Dum. Bibr. VIII, 598, pl. 98, (*Hyla*). *Nototrema* Gthr.

Nos. 28, Chimbote Valley; 127–8, Pisac; altitude 10,500 feet.

21. CHOROPHILUS CUZCANUS sp. nov.

A species of medium size in a genus where the species are never large. Form rather robust, head wide, flat; canthus rostrales well marked but contracted. Nostrils near the end of the muzzle, which is obtusely rounded. Tympanum distinct, its diameter half that of the eye slit, which is nearly as long as the muzzle in front of it. The limbs are rather elongate, and the digital dilatations are quite small. The wrist of the extended fore limb reaches the end of the muzzle, and the elbow is slightly overlapped by the knee when both are appressed. When the hind limb is extended forwards, the heel reaches to the line of the front of the orbit. There are no tubercles on the sole, and the skin of the superior surfaces of the body is smooth, while that of the thorax and abdomen is closely areolate.

The vomerine teeth are in two full and closely approximated fasicles between the internal nares, their posterior borders projecting a little behind the posterior margins of the latter. The nareal openings are small, and about equal to the ostiapharyngea; the tongue is discoid, and is openly notched on the posterior free border, which constitutes about one-third the length of the organ.

Color of the upper surfaces dark olive; of the limbs paler; the femur uniform light olive, posteriorly. Inferior surfaces dirty white, except those of the thighs, which are pale yellow. Sides of the head to the tympanum dark, bordered above by a blackish line along the canthus rostralis, and below by a light labial border.

	M.
Length of the head and body	.0230
Length of head to posterior line of tympanum	.0075
Width " at " " "	.0093
Total length of fore limb	.0165
" " " hind "	.0375
Length of foot	.0170
Length of tarsus	.0065

* Cope, Journal Academy, Phila. 1875, p. 175. † Loc. cit., p. 174.

This species is one of those forms which is near the boundaries of the families of *Hylidæ* and *Cystignathidæ*. It agrees with the other species of the genus to which I have referred it in essential respects; *i. e.*, in the free toes, the fronto-parietal fontanelle, and the small and separated prefrontals. The last two characters distinguish it from *Hylodes* to which it bears a superficial resemblance, as also the terminal phalanges, which lack the transverse limb of that genus. The sacral diapophyses are but little dilated. It is noteworthy that this frog is the first one which presents these characters, known from South America, all the species of *Chorophilus*, five in number, being North American.

22. CYCLORHAMPHUS ANGUSTIPES, sp. nov.

A species of medium size, remarkable for the small extent of the palmation of the toes. The muzzle is short and rounded, its profile retreating backwards to the superior, rather elevated plane. Canthus rostrales obsolete; nares one-third nearer to the border of the orbit than to that of the upper lip. The orbits look somewhat upwards and forwards, the tympanic membrane is not visible in the derm, but exists as a small vertically oval membrane whose long diameter is one-third the vertical diameter of the eye. The skin is everywhere perfectly smooth. The thumb and second finger are of equal lengths. The web of the hinder foot is deeply notched, the edge marking the middle of the first phalange of the fourth toe; that between the first, second and third toes joining the adjacent longer toe at a still lower point. The wrist of the extended fore limb exceeds the end of the muzzle, while the heel reaches to the nostril; the tibia equals the foot without the tarsus. The choanæ are larger, and the ostiapharyngea very small. The vomerine fascicles are small and close together; they fill the narrow space between the inner borders of the choanæ. The tongue is nearly round, entire, and has the posterior fourth free.

	M.
Length of head and body	.038
Length of head to posterior line of tympana	.011
Width of head at " " "	.019
Length of fore limb	.025
" " foot (greatest)	.010
" of hind limb	.061
" of hind foot	.029
" of tibia	.017

Color above, dark plumbeous; below, a light lead color.

No. 136, from Juliaca; altitude 12,550 feet.

The characters which distinguish this species from the *C. æmaricus*, are, the greater length of the limbs, the closer approximation of the choanæ; the absence of dermal margins to the toes, the absence of cuneiform tubercle, and the close union of the metatarsal bones in the sole. This arrangement gives the sole a narrow form, without the expansiveness seen in *C. æmaricus*, where the grooves between the metatarsals are distinct.

23. CYCLORHAMPHUS ÆMARICUS Cope. Proc. Acad. Phila. 1874, p. 125.

Nos. 48, 49, 50, from Yura, near Arequipa; altitude 8000 feet; Nos. 81–4, from Cuzco; altitude 11,000 feet. Specimens from Cuzco are darker colored than those from Yura. They are dark plumbeous with large round black spots above; the latter are lighter plumbeous with or without dark gray smaller spots. In males from the latter locality the thorax is covered with corneous asperities and there is a large shield of horn on the inner aspect of the thumb, which is covered with acute projections.

24. CYCLORHAMPHUS PUSTULOSUS, sp. nov.

The largest species of the genus, distinguished by its large head, and the prominent tubercles of the sides and coccygeal region.

The head is wide and flat, with the loreal region and the muzzle oblique. The canthus rostrales are obsolete, and the nares, although at the end of the superior plane of the muzzle, are equidistant between the orbit and the labial border. The membranum tympani is concealed by the skin and is a vertical oval, whose long diameter is less than half that of the eye slit. The fingers and toes are elongate, especially the last or ungual phalange; the wrist reaches considerably beyond the muzzle, and the heel to the front of the orbit. The hind foot is only half webbed, and is considerably longer than the tibia. The skin is smooth, excepting on the sides between the ilia round the vent, the superior face of the tibia, and the sole of the foot. These localities are all tubercular; the limbs with small acute warts, the side with small, obtuse, and very prominent warts, and the iliac region with larger obtuse warts.

The choanæ are not very much approximated, and the vomerine patches between them are very small. The ostia pharyngea are very minute and situated well within the external borders of the mouth. The tongue is wider than long, and entire.

Color, dark lead color everywhere excepting the gular region and the tips of the lateral warts, which are dirty white. Upper regions indefinitely shaded with brown and gray.

	M.
Length of head and body	.060
" " to posterior line of tympana	.018
Width of head at " "	.024
" of sacral expanse	.012
" of interorbital space	.005
Length of fore limb	.038
" of fore foot	.016
" of hind limb	.087
" of hind foot	.042
" of hind tarsus	.010
" of tibia	.025

No. 111, from Tinta; altitude 11,400 feet.

25. PLEURODEMA CINEREUM, sp. nov.

Muzzle oval, vertically truncate at the end and elevated; canthus rostrales obtuse, loreal region little oblique; nares terminal. Membranum tympani distinct, round, its diameter one-third that of the eye-slit. Wrist extending to muzzle, and the heel to the middle of the orbit. Two large palmar tubercles. Cuneiform tubercles of sole prominent, not sheathed with horn, the outer solar tubercle not prominent; no proximal tarsal tubercle. Tarsus short; remainder of foot longer than tibia. Skin with low warts on all the upper surfaces of the head and body; inguinal gland moderate, oval. Posterior inferior femoral region areolate.

The vomerine teeth are in small fasiculi extending backwards from the line of the anterior margins of the choanæ. The latter are twice as large as the small ostiapharyngea. The tongue is a wide oval, has a slit-like notch behind and is one-half free.

Color above gray leaden, with indistinct darker plumbeous spots, of which the largest is between the orbits. There are three wide vertical dark gray bands at the upper lip, the last one on the tympanum, and two paler similar bands between them. Numerous black spots on the groin; a black crescent on the inguinal gland. Limbs dark cross-banded above; posterior face of femur darkly gray spotted. Lower surfaces dirty white; gular region gray dusted.

	M.
Total length of head and body	.027
Length of head to posterior line of tympana	.008
" " at " " "	.010
Width of sacral expanse	.0055
Length of fore limb	.0170
" " foot	.0070
" of hind limb	.0410
" " foot	.0180
" of tarsus	.0050
" of tibia	.0110

No. 137, from Juliaca at 12,550 feet.

26. BUFO CHILENSIS Tschudi, Batr. 88. Dum. Bibr. VIII, 678. *B. spinulosus* Weigm.

Nos. 2 and 4, Pacasmayo on the coast; 47, Arequipa, 7,500 feet; 52, Chimbote Valley; 54–56 and 124–126, Urubamba, Eastern Peru, 10,000 feet; 73–9, Cuzco, 11,000 feet; 87–8, Yaurisque, East of Cuzco, on the Apurimac, 10,500 feet; 102–110, Tinta, 11,000 feet; 129–135, Juliaca, 12,550 feet.

Having arranged the above thirty-six specimens of this toad in the order of the elevation above the sea at which they were found, beginning at the coast, and rising to 12,550 feet, I have discovered no characters of surface, of color, or of any other kind which are related to the habitats. Two of the three specimens from Pacasmayo, ♂ and ♀, are twice the average size of the others; the third one is as large as the largest of the others. Several specimens have spinulose warts.

PISCES.

HYOPOMATA.

It has sometimes appeared to the writer that a modification might with advantage be introduced into the system of Fishes, as left in his synopsis of the osteology of the subject, published in the Transactions of the American Philosophical Society, 1870, p. 449, and the Proc. Amer. Ass. Adv. Science, 1871, p. 326. The sub-classes of fishes there recognized were five; viz. the *Holocephali*, the *Selachii*, the *Dipnoi*, the *Crossopterygia*, and the *Actinopteri*. As it appears that the structural differences existing between the last two divisions are not so great as those which distinguish the others, it is proposed to combine them into a single sub-class, to be called the *Operculata*. The definitions of the four sub-classes will then be as follows:

I. Suspensorium continuous with the cartilaginous cranium, with no hyomandibular nor rudimental opercular bone; no maxillary arch; pelvic bones present; axial series of fore limb shortened, the derivative radii sessile on the basal pieces; axial series of hinder limb prolonged in ♂. ..... *Holocephali.*

II. Suspensorium articulated with the cranium; no maxillary arch; no opercular nor pelvic bones; bones of limb as in the last ..... *Selachii.*

III. Suspensorium rudimental, articulated with cranium, supporting one or more opercular bones; cranium with superior membrane bones; no maxillary arch; a median pelvic element; the limbs supported by segmented unmodified axes..... *Dipnoi.*

IV. Hyomandibular and palatoquadrate bones articulating with cranium, supporting opercular bones; a maxillary arch; no pelvic element; axes of the limbs shortened, the derivative radii sessile on the basal pieces..... *Hyopomata.*

The primary divisions of the *Hyopomata* are indicated by the structure of the fins, of which there are three principal modifications, as follows:

A. Derivative radii present in both limbs; in the anterior supported by an axial segment with one or more basal or derivative radii, forming a peduncle; in the hind limbs the derivative radii sessile on axial segment only..... *Crossopterygia.*

B. Derivative radii few in the fore limb, sessile on scapula; present in hind limb, and sessile on axial segment.... *Chrondostei.*

C. Derivative radii few in the fore limb, sessile on the scapula; wanting or very few and rudimental on the hind limb so that the dermal radii rest on the axial element.... *Actinopteri.*

The classification of the *Actinopteri* then continues as in the memoirs above quoted.

27. CORVINA AGASSIZII Steindachner Sitzungsber, K. K. Acad. Wiss. 1875 (April), p. 26.

Nos. 5 and 43, from Pacasmayo and Chimbote Bays. These specimens have an indistinct longitudinal stripe extending along each row of scales above the middle of the body; cross-bands are not apparent. D XII-1-21; A 2-10.

28. BLENNIUS TETRANEMUS, sp. nov.

Radii; D. XIX-13; P. 13; V. I-3; A. II-18; first dorsal fin commencing above the preopercular border, with many of the rays of subequal length, which does not exceed the distance from their bases to the pectoral fin. An open notch between the first and the more elevated second dorsal fin. In only one out of seven specimens there is a pair of curved teeth behind the premaxillaries; none in the lower jaw. Interorbital space narrow, deeply grooved; behind the orbits a transverse groove behind which the vertex is swollen. A slender postnareal tentacle, a long tentacle above the posterior part of the orbit deeply split into four subequal portions; no fringes at its base nor behind the orbit.

Orbit a little more than one-fourth the length of the head; the head three and a-half times in the length without the caudal fin; depth four times in the same.

Color light brown, the sides marbled with darker brown; seven quadrate brown spots on each side of the base of the dorsal fin. Sides of head speckled with dark brown; a large brown spot behind the eye which separates two wide light bars, one of which extends downwards and backwards from the eye, and one backwards. Anal fin dusky with a light margin; dorsal with obscure brown shades.

	M.
Total length	.073
Length to base of pectoral	.019
" " ventral	.016
" " anal	.033
Diameter of orbit	.0045
" interorbital space	.0015

From Pacasmayo Bay.

29. CLINUS MICROCIRRHIS Cuv. Val. XI p. 384. Geog. Hist. Chile Zoöl. II p. 275. D. XXV-12; V. I. 3; A. II-22.

No. 39, from Callao Bay.

30. CLINUS FORTIDENTATUS, sp. nov.

A shorter species than the last with the external teeth in both jaws larger.

Radii; D. XIX-13; V. 15; V. 1-3; A. II-20; C. 1-12-1; the dorsal fin commencing above the preopercular border; the pectoral reaching to the base of the anal. Dorsal spines rather short, about half as long as the soft rays. The greatest depth is opposite the base of the pectoral fin; the front is regularly decurved to the rather compressed muzzle, where the

tips are about equal. Scales in a vertical line from the vent, 19-1-35. The diameter of the eye enters the length of the head 5.4 times; the head enters the length 4.17 times; and the depth into the same 4.5 times. There is a small cirrhus at the anterior nostril; a stout short one with a fringed border projecting from below the superior posterior border of the orbit, and a dermal flap with a fringed border on each side, extending from near the middle line, along the posterior border of the skull to opposite the superior third of the orbit. The teeth in both jaws are of two kinds; the external larger in a single row, and the internal smaller, in several rows of the former are stout and compressed, and considerably exceed in size the corresponding ones of the *C. monocirrhis*. The patches of small teeth are confined to the anterior part of the lower jaw, but extend a little further posteriorly in the upper jaw. The palatine teeth are few and coarse.

	M.
Total length	.233
Length to orbit	.022
" base of pectoral fin	.073
" " anal fin	.115
" " caudal fin	.023
Depth of body at origin of anal	.050
Interorbital width	.009

The color is a light, leathery-brown, with four vertical cross bars of a darker brown, of which lateral portion projects posteriorly from the dorsal portion. In addition to these, the body and head are thickly marked with small, dark-brown spots; similar spots on the dorsal caudal and base of pectoral fins.

No. 40, Callao Bay.

31. SICYASES PYRRHOCINCLUS, sp. nov.

A small species of rather slender form. The head is one-fifth of the total length including caudal fin; the depth of the body is one-eleventh of the same The long diameter of the orbit is one-fourth that of the head, exceeds the length of the muzzle, and enters the interorbital width one and one-half times. The front is flat, and the mouth very small, with a few large tridentate incisors, and a smaller number of smaller teeth on each side of them in each jaw. The incisors are six above, subvertical, and four below, subhorizontal. Radial formula D. 5; C. 1-7-1; A. 4; V. 4; P. 20. The posterior disc margin is wide, and extends in a broad lamina, vertically behind the pectoral fin. Pectorals and ventrals connected by membrane. Suctorial disc 5.6 times in total length; its anterior free margin narrow.

Measurements.	M.
Total length	.034
Length to anterior margin of disc	.0045
" " anus	.016
" " dorsal fin	.020
" " anal "	.021
" " caudal "	.028

The dorsal region is crossed by five wide brown spots, the anterior between the bases of the pectoral fins, those following becoming successively nearer together. They are all joined together on the sides by a brown border which presents processes downwards so as to be scolloped. Below this the surface is white. The dorsal spaces enclosed between the spots, together with the top and sides of the head are marked with a crimson network. Two chain-like bands on the operculum, and two on the base of the pectoral fin.

The precise locality from which this species was obtained, has not been preserved.

32. ATHERINA LATICLAVIA Cuv. Vol. X, p. 473.

No. 41, Callao Bay.

33. BELONE ?TRUNCATA Les. Gunther Catal. Fishes Brit. Mus. VI. p. 224.

Differs from Atlantic specimens in having the tail evenly though slightly emarginated. Radii; D. 14; A. 17. No. 42; from Callao Bay.

I find that in the genus *Belone*, the coronoid bone is distinct from the other mandibular bones, and is well-developed. In *Amia*, where it has been stated to be distinct, it is coössified in old individuals.

34. ORESTIAS CUVIERII Cuv. Val. XVIII p. 225.

Fin radii; D. 15; A. II. 16. Scales in fifty-three transverse series to above superior extremity of branchial fissure. Orbit one-fifth of head; length of head 3.5 times in total without caudal fin. Top of head and each side of anterior dorsal region naked.

No. 142. Lake Titicaca.

35. TETRAGONOPTERUS IPANQUIANUS, sp. nov.

This species is furnished with a series of teeth on the maxillary bone as in the *T. pectinatus*, *T. polyodon*, etc., but is only camparable to the latter in adding to this character, a reduced number of radii of the anal fin. It differs from it in the smaller and more numerous scales.

The head is short, and the lower jaw robust and somewhat protuberant. Its length enters the total with caudal fin 5.75 times; it includes the diameter of the eye four times, which enters the diameter of the very convex interorbital space 1.6 times. Muzzle abruptly descending, shorter than orbit. The proximal two-thirds of the maxillary bone toothed. Dorsal fin originating behind the basis of the ventral, its last ray standing above the first anal ray. Caudal fin deeply forked, the superior lobe larger. Radii; D. I. 9; A. I. 28. Scales 11–54–61–8. The general form is moderately elongate, the depth entering the length without the caudal fin, three and one-fifth times.

	M.
Total length	.125
Length to orbit	.005
" " dorsal fin	.044
" " anus	.051
" " anal fin	.057
" " caudal fin	.093

Color silvery, with a narrow dorsal dusky line, and a leaden shade along the upper part of the side, which continues to the notch of the caudal fin. The anterior part of this band is enlarged into a scapular spot.

Nos. 69–70 and 122 from the upper waters of the Urubamba, one of the sources of the Ucayale. The other species of this section of the genus, the *T. polyodon* Gthr. is from the neighborhood of Guayaquil.

Dedicated to the memory of the inca Ypanqui, who in the city of Cuzco on the Urubamba, the first of his line, devoted himself to monotheism.

36. ENGRAULIS TAPIRULUS, sp. nov.

There are minute teeth in both the jaws, and the obliquely truncated extremity of the maxillary bone does not reach the articulation of the mandible with the quadrate. None of the fin rays are elongate, and the muzzle projects in a compressed, conical form beyond the mouth. The length of the head exceeds the depth of the body, and enters the total length without the caudal fin, three and one-third times. The depth of the body enters the same, four and one-fifth times. The eye is large, the diameter entering the length of the head four and one-half times, and exceeding the length of the rather elongate gill-rakers. Fin radii; D. I. 11; A. 25; the former originating above a point behind the base of the ventral fins; its last rays standing above the base of the first anal ray. Its first ray is equidistant between the base of the caudal fin, and the line of the anterior border of the orbit. Scales in 36–7 transverse series, deciduous. Abdomen moderately trenchant.

	M.
Total length	.120
Length to orbit	.006
" " border of operculum	.080
" " ventral fin	.050
" " anal "	.070
" " caudal "	.100

This species is, according to the descriptions given by Dr. Günther, most nearly allied to the *E. surinamensis*, and *E. poeyi*, but differs in many respects. The two specimens probably came from Pacasmayo Bay.

37. TRICHOMYCTERUS PARDUS Cope, Proceedings Academy, Phila. 1874, p. 132.

Numerous specimens from Jequetepeque.

After comparison of this first with many individuals both old and young, of the *T. dispar*, my opinion in favor of its specific distinctness from that species is confirmed. In order to present its characters in connection with those of other *Trichomycteri*, the following table is presented. A large specimen of the *T. pardus*, which, according to the label, came from Callao Bay, differs from those from Jequetepeque in having small spots instead of the large blotches characteristic of the species:

I. Dorsal fin entirely in front of anal.

a. Dorsal partly over base of ventrals.

Head one-sixth total length;* D. 7–8; A. 5–6; form slender; spots few, large..... *T. pardus.*

II. Dorsal fin partly over anal fin.

a. Dorsal fin partly over ventrals.

Head 4.5 to 5.5 in total length; D. 9; A. 6; gray, uniform or black speckled..... *T. dispar.*

aa. Dorsal fin behind base of ventrals.

Head 5 times in total; D. 7; A. 5; closely marbled with dark brown above and below..... *T. rivulatus.*

Head 6 times in total; D. 7; A. 6; straw-colored with a few faint specks..... *T. gracilis.*

Head 6.5 and 7 times in total; D. 8; A. 6; coarse, brown, confluent blotches, finer above anteriorly; forming two series posteriorly with pale band between..... *T. poeyanus.*

The species *T. maculatus*, *T. punctulatus* and *T. areolatus* C. & V., are characterized by a larger number of rays (11–15) in the dorsal fin, than that found in any of the preceding.

33. TRICHOMYCTERUS DISPAR Tschudi; Günther, Catal. Brit. Mus. V, p. 273.

All the specimens of this species as above defined come from the headwaters of the Amazon, as was found to be the case by Tschudi (see Fauna Peruana). They are Nos. 89 and 92–4 and 101 from Tinta on the Vilcanota, the source of the Ucayali, elevation 11,400 feet; Nos. 57–60 and 113–121 from the Rio Urubamba at Urubamba, elevation 10,000 feet. The very young have an interrupted dark lead-colored lateral band, which with growth is resolved into spots, and disappears. None of the specimens present the numerous dorsal radii ascribed by Dr. Günther to his *T. dispar*, which is doubtless the *T. maculatus* of Cuv. Val.

39. TRICHOMYCTERUS RIVULATUS Cuv. Val. Vol. XVIII, p. 495.

This species, which is characterized by a smaller number of dorsal radii than the last, among other points, is represented by a large specimen (No. 143) from Lake Titicaca. Native name, Suche.

40. TRICHOMYCTERUS GRACILIS Cuv. Val. XVIII, p. 497.

The principal characters of this fish have been already pointed out. I add the following:

The depth of the body is one-sixth the total length with caudal fin. The eye is a little nearer the line connecting the posterior borders of the opercula than that which is tangent to the end of the muzzle. Nasal barbel extending a little beyond the eye. Radii; D. 6½; C. 4–11–3; A. 5½; V. I. 5; P. 9.

The color is a greenish straw-color with very faint dots closely placed on the dorsal region; lower surfaces unicolor; spots more distinct on top of head. An indistinct dark band extends on each side of the dorsal region from the beard to behind the dorsal fin.

* Including caudal fin.

	M.
Total length	.290
Length to end of operculum	.042
" " ventral fin	.140
" " vent	.151
" " dorsal fin	.160
" " anal "	.170
" " caudal "	.250

This species resembles the light varieties of the *T. dispar*, but differs in the more posterior position of the dorsal fin, and the smaller number of its radii.

No. 91, large specimen from Tinta

I give the above description of a species probably named by Cuvier and Valenciennes, but no one can ascertain from their writings whether this is the case or not.

41. TRICHOMYCTERUS POEYANUS Cope, sp. nov. *Trichomycterus rivulatus* "Cuv. Val." Cope, Proceed. Academy, Philada. 1874, p. 132.

This species, formerly identified by me as above, I now name, dedicating it to my friend Prof. Felipe Poey of Havana.

42. ARGES SABALO Cuv. Val. XV, p. 335. Nos. 62–6 and 115 and 123, from the Rio Urubamba, at an altitude of 10,000 feet.

43. OPHICHTHYS UNISERIALIS, sp. nov.

Maxillary and mandibular teeth acute, in two series; premaxillary and vomerine teeth in single series; no distinct canine teeth, the premaxillaries the largest. Cleft of the mouth moderate, two-fifths the length of the head, which is one-half that of the body. Muzzle slightly projecting more than twice as long as the diameter of the eye. Body less than half as long as the tail. Pectoral fin a little more than one-third the length of the head, the dorsal originating nearly above its posterior sixth. Free portion of the tail very short; the terminal inch of both dorsal and anal fins enclosed in a deep groove between two vertical dermal laminæ. Length M. 0.330.

Color above dark brown, below a little paler, the two colors separated by a water line. Along the lower border of the dark brown is a series of small yellowish spots a half inch apart, which are invisible on the posterior half of the length.

From Peru, probably Pacasmayo.

A species allied to the *O. parilis* and *O. dicellurus* of Richardson.

44. MUSTELUS MENTO, sp. nov.

Snout elongate, the length anterior to the mouth, exceeding the width between the external borders of the anterior nostrils, and considerably greater than the length between the angles of the mouth, external measurement. Anterior base of the anterior dorsal fin above the middle of the inner border of the pectoral fin; the extremity of posterior portion reach-

ing the line drawn vertically from the base of the ventral fin. The posterior extremity of the base of the second dorsal stands above the beginning of the last third of the base of the anal. The proximal portion of the inferior limb of the caudal fin, is very little prominent. The teeth are transverse and present only a low transverse median keel.

Uniform leaden brown above; below light yellowish brown.

	M.
Total length	.303
Length to bases of superior teeth	.026
" " pectoral fins	.072
" " ventral fins	.143
" " anal fins	.202
Width between upper lips at angle of mouth	.019

From the Pacific Ocean at Pacasmayo, Peru.

This shark differs from the species described by Günther in the relatively long muzzle and narrow arcade of the mouth, excepting in the case of the *M. manayo* Schleg., which differs from the *M. mento* in the more posterior position of the dorsal fin. Prof. Gill has described two species from the Pacific Ocean, the *M. californicus* and *M. dorsalis*.* The former differs from the present one in the more posterior position of the ventral fins which are considerably behind the posterior angle of the dorsal, and the muzzle is shorter. In the *M. dorsalis* from Panama the dorsal fin is, according to Prof. Gill, more posterior in position, since only one-fourth of its base stands above the pectoral; in *M. mento*, three-fourths of the base of the dorsal stands above the ventral fin.

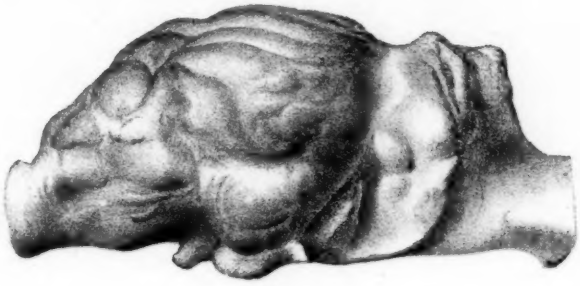
45. PSAMMOBATIS BREVICAUDATUS, sp. nov.

Anterior borders of the disc broadly rounded, consisting of the anterior portions of the pectoral fins, the only indication of the snout being a small tubercle below the median point. Disc broader than long, subrhombic, the lateral margins broadly rounded. Posterior border of pectoral fin overlapping the anterior part of the ventral. Ventral fins with the border not very deeply emarginate. Tail only one-fifth longer than the claspers, with broad lateral fold, two superior, and a rudimental terminal fin. Nasal fissures with two laminæ, which are not united with each other nor with those of the opposite side. The posterior or internal is anteroposterior, the anterior or external, is rolled into a tube.

The distance between the outer margins of the nostrils is equal to that between each one and the extremity of the snout, and one-half greater than that between each and the nearest part of the margin of the disc. The interorbital space is little concave, and is wide, exceeding the combined length of the orbit and spiracle. The upper surface of the head, and a broad band on both surfaces of the anterior part of the disc are covered with minute spinules. The other surfaces are smooth, with the following exceptions. Two spines anterior to the orbit above; a spine near the

* Proceedings Academy, Phila., 1864, p. 148–9.

1



3

2

Procamelus occidentalis ⅔.

inner border of the spiracle. A row of a few spines between the orbit and the lateral free border, nearer the latter; six or eight on the median line of the middle portion of the back; a double row parallel to the border of the pectoral fin, extending an inch within it, on its anterior half only; a series on the median line of the tail.

	M.
Total length	.307
" width	.270
Length to mouth	.038
" " vent	.190
" " base of tail	.215
Expanse of ventral fins	.137
Interorbital width	.029

Upper surfaces lead colored with indistinct darker shades; middle of the anterior portion of the muzzle pale, with a dark spot behind it.

From the Bay of Pacasmayo, Peru.

On the Brain of Procamelus Occidentalis.

By E. D. Cope.

(*Read before the American Philosophical Society, May* 4, 1877.)

I obtained a complete cast of the cranial chamber of the *Procamelus occidentalis*, which bears a fair proportion to the general dimensions of the skull. As compared with a llama of about the same size, the facial portion of the skull is longer, while the postorbital portion is as long, but narrower. This is indicated by the following measurements:

	Procamelus occidentalis.	Auchenia lama.
Length of skull anterior to orbit	.180	.153
" " posterior "	.110	.105
Width " at anterior border of orbit	.080	.090
" " middle of zygomatic fossa	.062	.065

The olfactory lobes of the brain have nearly the same position in the two species, extending anteriorly to opposite the middle of the orbits.

The brain exhibits large cerebellum and hemispheres, and rather small olfactory lobes. The cerebellum is entirely uncovered by the hemispheres but is in contact with them. The lateral lobes and vermis are well developed. The hemispheres are well convoluted, the longitudinal posterior convolutions giving way anteriorly to lobulate ones. The sylvian fissure is well marked. The sides of the medulla oblongata are compressed and vertical at the pons, in correspondence with the vertical position of the petrous bones. The origins of the ophthalmic and maxillary branches of the trigeminus nerve are not divided by a septum, while that of the man-

dibular branch is quite distinct from the others. The optic nerves are large. The olfactory lobes are separated by a deep fissure below the extremity of the hemispheres; they project freely beyond the latter, being separated by a deep fissure. Their free portions are short, truncate and compressed. The anterior pyramids are not preserved on the inferior face of the cast of the medulla oblongata. The hippocampal lobes are subround and protuberant.

From the detailed description following, it may be derived, that while the arrangement of the convolutions of the anterior lobes of the hemispheres is more simple than in any recent Ruminant, that of the middle and posterior lobes is essentially similar to that characteristic of the latter order of *Mammalia*.*

The brain displays the characters of the older types of *Ruminantia*, although not materially smaller than that of the llama, an animal which it equaled in general proportions. The hemispheres are, however, not produced so far posteriorly in the *Procamelus* as in the *Auchenia*, reaching only to the line of the *meatus auditorius externus* in the former.

The vermis of the cerebellum rises abruptly from the medulla, having a nearly vertical direction to a point a little lower than the superior plane of the hemispheres. The lateral lobes extend on each side of it, each one having a rather greater width that the vermis. Their posterior faces are sub-vertical, and are directed slightly forwards. Each projects laterally into an apex at the middle of its elevation, and then contracts downwards into the angular line which marks the posterior border of the petrous bone. From a point between each apex and the vermis a ridge rises obliquely inwards to the superior plane of the cerebellum, where each one enlarges and joins the median transverse line. The angle above described as descending from the lateral apex of the cerebellum curves forwards, forming a lateral angular border of the pons varolii on each side. The flat space enclosed between this line and the posterior border of the hemisphere is interrupted by two prominent tuberosities. The superior is small, sub-oval, and is near to the posterior border of the hemisphere. The other is a short prominent ridge directed downwards and forwards, just behind the lobus hippocampi. Its inferior end corresponds with the origin of the mandibular branch of the trigeminus, and perhaps the facial nerve.

The medulla oblongata is contracted at the foramen magnum, and has a sub-round section slightly flattened below. Its inferior face is then rounded, then flattened, and then concave between the anterior part of the lateral ridges. The bases of the maxillary branches of the trigeminus nerves are stout, and directly in line with the origins of the mandibulars. Between them the base of the brain is concave, and the optic nerves issue but a little distance in front of them. The lobi hippocampi are sub-round and rather prominent; they are terminated in front at the foramen sphenoorbitale by the contraction of the cranial walls. Their surface displays

* See Paul Gervais' Journal de Zoölogie, I, 1872, p. 459.

slightly defined convolutions, the best marked being inferior and subround in form.

The cerebral hemispheres, viewed from above, have an oval outline, and are rather narrower anteriorly than posteriorly. They contract posteriorly from the sylvian convolution. The profile descends gradually to the olfactory lobes. The superior surface is little convex in the transverse direction. The fissure of Silvius is nearly vertical in position, and its superior extremity is visible from above. A strongly marked fissure extends posteriorly from it, defining the lobus hippocampi above. The sylvian convolution the thickest of all, and its outer border is emarginate in front and behind; below the postero-superior emargination it is thickest and most protuberant. Between it and the position of the falx there are three longitudinal convolutions, the external, the median, and the internal. These are slightly divergent posteriorly, but the posterior extremities of those of one side tend to unite on the posterior border of the hemisphere. Their surfaces are smooth. The external is widest medially; and it terminates anteriorly just behind the apex of the sylvian convolution. The internal is double posteriorly; the median is simple, and unites with the internal above the apex of the sylvian convolution. The two conjoined continue for a short distance and terminate in a broad tuberosity. Below the external convolution on the side of the posterior part of the hemisphere there are four small longitudinal convolutions. The orbital portion of the hemispheres is extensive, and nearly smooth from the olfactory lobes to the supraorbital border. This is not prominent, but is represented by a short longitudinal ridge. Above each of these, on the superior or front aspect of the hemispheres, is a massive convolution bent crescent-shaped, with the convexity inwards. The posterior part of the convolution is a sub-round tuberosity which stands opposite to, and in front of, the furrow separating the sylvian and median convolutions. The middle part of the crescent is less prominent, but the anterior extremity forms another tuberosity whose long axis is directed downwards and outwards. The crescentic convolution of the one side is separated from that of the other by a wide, shallow, median longitudinal groove, which extends transversely at the posterior tuberosities. The two tuberosities and the olfactory lobes form three descending steps.

As compared with the brains of the existing *Bovidæ* that of the *Procamelus* differs in the forms of the cerebellum and medulla oblongata as already pointed out. The hemispheres differ in being shorter behind and more depressed in front. The convolutions of the posterior region are the same in number as in the sheep, but are less undulating in their outlines; but there is a marked difference in the anterior convolutions. The median convolutions do not, as in the sheep, extend to the extremity of the anterior lobe, but terminate above the sylvian fissure, so that there only remain in front of them the two large supraorbital convolutions, instead of the four common to existing *Bovidæ* and *Cervidæ*.* In this respect it more nearly

* See Leuret et Gratiolet Anatomie comparée du Systeme Nerveux, 1839–57, Atlas, pls. vii–x.

resembles *Oreodon*, but in this genus the internal convolution is continuous with the supraorbital.*

EXPLANATION OF PLATE.

Brain of *Procamelus occidentalis* from a cast, two-thirds the natural size.
Fig. 1. View of the left side.
Fig. 2. View of the superior surface.
Fig. 3. View of the inferior surface.

On the Vertebrata of the Bone Bed in Eastern Illinois.

BY E. D. COPE.

Read before the American Philosophical Society, May 20, 1877.

It is already well known that a few years ago, Dr. J. C. Winslow discovered in the Eastern part of the State of Illinois, a bone bed containing the fragmentary remains of reptiles and fishes. From some of this material placed in my hands, I identified four species of Vertebrata, two Rhynchocephalian reptiles, one a Dipnoän and one Selachian fish†. These were named, *Cricotus heteroclitus, Clepsydrops collettii, Ceratodus vinslovii,* and *Diplodus* sp. indet. It was stated in connection with the descriptions of these, that they indicate Triassic or Permian age for the bed in which they were found, since on the one hand *Reptilia* have not been found in the coal measures, nor on the other hand has the genus *Diplodus* been found above the Carboniferous series of rocks.

Doctor Winslow, in response to my inquiries, has sent for my examination another series of these fossils, which contains several species not previously known from the formation. Subsequently William Gurley discovered another exposure of the bone bed, and obtained a number of useful specimens, including some of species not previously known, which he also kindly placed at my disposal. To both these gentlemen I desire to express my sense of the obligation under which they have laid me. Descriptions of some of the species are now given; a complete account of the fauna is reserved for an illustrated memoir now in preparation.

STRIGILINA LINGUÆFORMIS Cope, gen. et sp. nov. Petalodontidarum.

Char. Gen. The tooth is a flat osseous plate whose outline is pyriform, the wider end recurved in one direction as the transverse cutting edge; the other extremity narrowed and recurved in the opposite direction as the root. The side from which the cutting edge arises is crossed by numerous plicæ from the base of the root to near the base of the cutting edge; the opposite side is smooth.

The genus appears to resemble most nearly the *Climaxodus* of McCoy,

* Leidy, Extinct Fauna, Dak. and Nebraska, pl. xiv, fig. 11.

† Proceedings Academy Philadelphia, 1876. p. 404.

especially such species as the one figured by T. P. Barkas in the Atlas of his Manual of Coal Measure Paleontology Pl. I figs. 35-7 (Manual p. 20). From the latter it differs in the transverse instead of continuous relation of the edge and root to the main body of the tooth; the root does not appear to be differentiated at all in *Climaxodus*, while it is distinctly marked in *Strigilina*.

Char. Specif. The plicate surface terminates behind in a median angle, at the base of the root. There are eight plicæ which all cross the plane, excepting the sixth, which is interrupted in the middle by the strong angulation of the seventh, which touches the fifth. The lateral extremities of the right are in contact with the base of the recurved cutting portion. The latter is convex transversely, leaving a smooth surface between it and the eighth plica. The smooth side of the tooth is shining, and there is a shallow fold which passes round its side and crosses just at the base of the recurved cutting lamina. The edge of the lamina is unfortunately broken.

	M
Total length of plane	.008
Width at base of cutting lamina	.006
Width at base of root	.004
Thickness of plane portion	.0015

This species was found by William Gurley.

SELACHII.

DIPLODUS ?COMPRESSUS Newberry.

A few teeth of *Diplodus* found, are none of them perfectly preserved. One with a lateral and median denticles nearly complete, agrees pretty well with the species cited.

DIPNOI.

CERATODUS VINSLOVII Cope Proceed. Acad. Philada. 1876, p. 410.

CERATODUS PAUCICRISTATUS Cope, sp. nov.

The single tooth representing this species is narrow in the transverse direction, but stout in vertical diameter. But four ridges are present, all of which have a single direction, but the shorter ones are the less oblique to the long axis of the tooth. They all extend into the inner border, but become low as they approach it. Distally they are quite prominent, but do not project very far beyond the emarginate border between them. The inner border is plane and vertical, and without ledge; the inferior surface is concave in the transverse direction. The surface of the tooth is minutely and elegantly corrugated.

Length from base of second rib	.0170
Depth at base of second rib	.0045

From the collection of Dr. J. C. Winslow.

CTENODUS FOSSATUS Cope, sp. nov.

Represented by a nearly perfect tooth of a general narrow and vertically thickened form. There are five crests, the largest three extended in one

direction, and the other two in the other. Between the last of the latter and the inner border is a rudiment of another in the form a rugosity. None of the crests touch each other at their bases. At their extremities they curve rather abruptly downward, and do not project beyond the inferior plane, from which each one is separated by a deep fossa, whose mouth is a notch in its base. The crests are coarsely dentate, there being three or four teeth on each, and the grooves between them are marked by coarse transverse undulating grooves. The inner border is a deep vertical plane; the inferior face is narrow and concave in transverse section.

Total length	.022
Greatest width	.007
Depth at middle	.006

This is the first species of this carboniferous genus found at this locality. It differs from the *C. serratus* Newberry in its narrow form, small number of ridges, and the very slight prolongation of their extremities.

CTENODUS GURLEYANUS Cope, sp. nov.

This species is indicated by a portion of a tooth, which leaves the number of the ridges a matter of uncertainty. On this account its description might have been postponed, but that the distinctness of its characters, render it clear that it cannot be placed with any of the other species. The crown, as in *Ceratodus paucicristatus*, is narrow and rather thick; but three crests are present, all radiating in the same general direction, the longer close to the inner border. There was not more than one additional crest, or one and a rudiment, and these have probably the same direction as those which are preserved. The crests are sharp, elevated, and coarsely dentate; they are not decurved at the extremity, but cease abruptly with a projecting denticle, beneath which the basis is excavated by a shallow fossa. The inferior face is slightly concave, the internal wall vertical.

Greatest width	.008
Depth at inner border	.005

This *Ctenodus* is dedicated to William Gurley, to whose efforts science is indebted for this and several other interesting paleontological studies.

CROSSOPTERYGIA.

PEPLORHINA ARCTATA sp. nov.

Based on an unsymmetrical bone, bearing teeth, to be referred to the position of pharyngeal, pterygoid, palatine, or half of the vomerine elements. From the resemblance of the teeth to those on the palate of *Peplorhina anthracina*, I refer it provisionally to the corresponding position in the mouth of a second species of that genus. This course is open to modification should subsequent investigation require it.

The bone is plate-like and diamond-shaped, with the longer angles both recurved. The convex surface is thickly studded with teeth, which are not in contact with each other. Their size increases from one side of the

bone to the other, and still more, from one extremity to the other. The crowns are swollen at the nearly sessile base, and contract rapidly to a conical and unsymmetrical apex. Those of the smaller teeth are more conical, those of the larger more bulbiform. One side of the latter is slightly concave below the apex. The surface is shiny and distinctly grooved. Fractured crowns do not display any central cavity. There are sixty-five teeth on the plate.

Length of plate	.013
Width on short border	.007
Transverse width	.007
Depth	.002

OTHER TEETH.

Teeth of four other species have been found by Doctor Winslow, to which I allude only briefly, as their characters are not sufficient to enable me to distinguish them from those of known genera and species.

Species one. This is represented by a fragment of mandibular ramus, which supports six teeth, all of which have a greater or less part of their apices broken away. They stand in close juxtaposition, and are of equal sizes. The basal half or more of the crown displays the character of deep inflections or grooves. These teeth belong to some sauroid fish, or to a batrachian.

Specie two. This is also represented by a portion of mandibular ramus which supports four teeth. The anterior of these is larger, and is separated from the others by an edentulous space. Their crowns are rather elongate and are compressed, having cutting edges fore and aft. Both edges contract to the apex, but the anterior the most so. There are a few shallow grooves at the base, but they appear to be superficial only. These teeth might belong to either a reptile or a batrachian, and it is useless to attempt to distinguish them by a name from the many genera of both classes that resemble them.

Species three. Two stout, slightly flattened, conic teeth without cutting edges, represent this species. They are anchylosed to a very thin plate of bone, a part of which adheres to each. The base is oblique, expanding more in one direction than another. The greater part of the crown is marked by closely placed parallel grooves, which are much more numerous than in the species No. 1. They are larger than these or No. 2, measuring .004 in diameter at the base. They may belong to any one of a number of known genera of Batrachia, or Sauroid fishes.

Species No. 4. These are more numerously represented than the others, occurring in Mr. Gurley's collection as well as in Dr. Winslow's first collection. There is nothing to prevent their reference to the *Lacertilia*, and I have thought that there is some probability of there being referable to the *Clepsydrops collettii*. They are not rooted, but are anchylosed in a shallow concavity of the jaw bone, which is only distinguished from that for the adjacent tooth by the corresponding scolloping of the lower margin

of the jaw. The opposite margin is a little more elevated and is more closely anchylosed to the base of the tooth. The crown is conic, subround in section, and curved backward. There are no cutting edges, and the base is a little flattened in front and in behind. On each of the faces thus formed, there is an open, shallow groove, sometime obsolete. There are no other grooves nor sculpture on the teeth.

Each specimen of this tooth is single, and anchylosed to the same (corresponding) part of the jaw. The tooth is at one extremity of the alveolar groove; above the opposite end is the basis of a bone attached at right angles (? prefrontal or malar). One of the specimens displays an extensive pulp cavity.

Length of crown	.010
Diameter at base	.004

ACTINOPTERI.

In the transactions of this Society, published in 1871, and more fully in the Proceedings of the American Association for the Advancement of Science, at the meeting of 1871 (published early in 1872), I showed that the supposed order of Ganoids as defined by Müller, is not a homogeneous or natural association of types. I pointed out that the recent genera must be distributed between two divisions of fishes of high rank, viz.: the *Crossopterygia*, and the *Actinopteri*. The last-named division was believed to include the fishes previously known as *Chondrostei* and *Teleostei*. Some of the so-called Ganoids of Müller and Agassiz were referred to different subdivisions of the *Actinopteri*. In a paper recently published in the Proceedings* of this Society, a better expression of natural affinities was thought to be obtained, by regarding the *Crossopterygia*, the *Chondrostei*, and the *Actinopteri*, as forming a single sub-class of the class Pisces, under the name of *Hyopomata*, the other sub-classes being the *Dipnoi*, the *Selachia*, and the *Holocephali*.

I had already referred *Phaneropleuron*† to the *Dipnoi*, when Dr. Günther's and Prof. Huxley's researches into the structure of *Ceratodus forsterii* led them to place this genus also in the same sub-class. Günther also refers the fossil genera *Dipterus*, *Chirodus* and *Conchodus* to the *Dipnoi*, and with these must go *Ctenodus* and its immediate allies. The *Polypteridæ* and *Cœlacanthidæ*, which were arranged by Huxley, with the preceding forms in his sub-order *Crossopterygia*,‡ are clearly *Hyopomata*, having well developed hyomandibular and maxillary bones, as well as characters of the pectoral fins equally wanting to the *Dipnoi*. It is thus evident that the division *Crossopterygia*, as left by Huxley, cannot be maintained, but that it must rest entirely on the definitions given by me in the papers above quoted, where the two families mentioned were the only ones referred to it. It is possible that a strict adhesion to the law

* May, 1877.

† Transactions American Philosophical Society, XIV, 1871, p. 450.

‡ Memoirs of the Geological Survey, Great Britain, Decade X.

of priority will require that the name *Ganoidei* should be retained for this division.

The tribe *Actinopteri* as left in my latest paper above quoted (May, 1877), has slightly different boundaries from those originally prescribed for it, since the *Chondrostei* are now excluded from it. As then and now understood, it is nearly identical with the *Teleostei* of Müller, a name which I should adopt for it, were it not that some of his *Ganoidei* and numerous extinct forms with unossified vertebral column belong to it. For such fishes the name of Müller is too glaringly inapplicable to be employed.

After excluding the extinct genera of *Hyopomata* which are clearly *Crossopterygia* and *Chondrostei*, there remains a numerous assemblage, whose relationships to existing types of fishes have never yet been ascertained. I refer especially to the families of the *Lepidoides*, *Sauroides* and *Pycnodontes*, of the Poissons Fossiles of Agassiz, and other forms subsequently described; among others, the *Dorypterus* of Germar. The only bond which retained these forms in connection with the fossil Crossopterygian fishes, the rhombic and enameled scales, may be safely disregarded in view of the important characters of the skeleton which declare their affinities to be diverse; the more as some of the latter (*Cœlacanthidæ*) have rounded scales, and *Leptolepis* and other genera referred by Agassiz to the Sauroides, have cycloid scales. The heterocercal character of the tail of some of them, is of but little greater weight. I have already shown that fishes presenting this character (*Lepidosteus*, *Amia*) do not differ in other respects from other *Actinopteri*, while the still lower isocercal condition is often seen in the latter. Further, the extinct genera do not agree among themselves in this respect, some bring heterocercal, and some isocercal.

The question remains as to the proper location of the families just named, in the tribe *Actinopteri*. It has been impossible to discover all of the characters necessary to the fullest elucidation of this question, but the greater number of them have been satisfactorily ascertained. The following results are therefore approximations to the truth which I believe that future researches into the osteology will confirm. At the least they are much nearer to an expression of nature than any yet attained.

As regards the general affinities represented by the terms *Physostomi* and *Physoclysti*, there is no doubt that the *Lepidoides* and *Sauroides* exhibit the former. This is seen in the uninterrupted conjunction of the parietal bones (where it has been possible to observe the parts), and in the abdominal position of the ventral fins, and extent of the maxillary bone; as well as in the less important features of the absence of all ctenoid characters of scales and preoperculum, lack of spinous rays, etc. The *Pycnodontidæ* present in general similar characters, and add nothing which should separate them widely from the Lepidoid genera of Agassiz, especially the family of the *Dapediidæ*. Like these, however, they approach nearer to the *Physoclysti* in the anterior continuation of the interneural spines as far as the skull. This character is found also in some *Physostomous* fishes, *i. e.* the greater number of *Characinidæ*, the *Elopidæ*, *Umbridæ* and some

Nematognathi. The *Dorypteridæ* present a number of peculiar features, approaching still more closely the *Physoclysti* in their thoracic ventral fins.

We may now consider the relations of the Lepidoides and Sauroides to the known physostomous orders.

The scapular arch being suspended to the cranium renders comparison with some recent orders with a free scapular arch, unnecessary. The simplicity of the anterior vertebræ leaves out of account the *Nematognathi* and *Plectospondyli.* The only orders with which we can compare them are those represented by their old companions in the Poissons Fossiles, the *Ginglymodi,* the *Halecomorphi* and the *Isospondyli.*

Although the *Sauroides* included the genus *Lepidosteus* in Agassiz's system, I cannot find that any of the fishes of the two families under consideration possess the peculiar vertebræ of that genus, which in part characterizes the order *Ginglymodi.* Neither have any of them the segmented maxillary bone. The real alternative is between the last two of the above named orders. Now the principal skeletal character which distinguishes these two, is found in the pectoral fin. In the *Halecomorphi* there are numerous basilar radii attached to a cartilaginous mesopterygium, in the *Isospodyli* there are but three or four such bones sessile on the scapular arch. After examining a number of specimens of species of both the Agassizian families named, I have been unable to discover any basilar bones whatever, and have suspected that they were, in the complete skeleton, of cartilaginous character, Professor Agassiz figures this region in his restoration of the "Lepidoid" genus *Platysomus,* and of the "Sauroid" genera *Macrosemius* and *Caturus.* In these, he represents the small number of basilar bones characteristic of the *Isospondyli,* and placed in the close relation to the scapular arch, which is seen in the same order. A consultation of the numerous figures given by Agassiz, Thiolliere, and others, has failed to discover a single instance exhibiting the peculiar basilar pectoral bones of *Amia.* This could scarcely be so uniformly the case did such bones exist, so that with Prof. Agassiz restorations coinciding, I can only for the present refer these fishes to the *Isospondyli.*

Their other special characters are so numerous, that they must be taken account of in deciding on their ordinal relations. If we, for the present, distinguish the two families as did Agassiz, we include in the Lepidoides the genera with teeth *en brosse* or in a single row, and sub-equal and obtuse; and in the Sauroides the genera with teeth of unequal sizes, some being large and raptorial, the others minute. Of the Lepidoid genera, Agassiz states that the vertebræ are osseous in *Lepidotus,* and says the skeleton of *Amblypterus* is osseous, without particularizing the vertebræ. The posterior vertebræ of *Palæoniscus* he states to be ossified, while in *Platysomus, Tetragonolepis* and *Dapedius,* the centra are not certainly osseous. In all of these genera the neural and hæmal arches are distinctly articulated with the centra. *Platysomus, Dapedius* and *Tetragonolepis,* present the important character of a series of basilar interneural and interhæmal bones, the interneurals commencing in *Platysomus* at the head.

This character separates these species widely from the other genera of the "*Lepidoides.*"

As regards the "*Sauroides,*" the vertebral centra are always represented as ossified, and the neural and hæmal arches articulated, with the possible exception of *Thrissops** where the arches are represented as continuous; the same point is not certainly determined in *Eugnathus.* None of the genera which I have seen, have the basilar interneural and interhæmal spines found in the *Dapediidæ,* above mentioned, nor are they figured or described by authors.

In these characters of the two groups, there is nothing allying the genera to the *Halecomorphi* rather than to the *Isospondyli.* The absence of the basilar interhæmals from all excepting the *Dapediidæ* is additional evidence of Isospondylous affinities. The ganoid scales of most of the genera, do not separate them from the typical forms of this order more widely than the *Arapæma,* nor the vertebrated caudal fin more widely than the existing *Notopterus.* The number of vertebræ included in the axis of the caudal fin in the extinct genera is shown by Agassiz to be very variable. In *Megalurus,* this region resembles that of *Amia;* in *Leptolepis* and *Caturus,* the vertebræ are not more numerous than in the *Saurodontidæ,* while in *Thrissops* the fin is homocercal, in the Agassizian sense.

As already remarked, the *Pycnodontidæ* present some points of resemblance to the *Dapediidæ.* All the points necessary to a complete elucidation of their structure have not yet been observed, so that my conclusions are necessarily imperfect. A point of resemblance to the *Plectognathi* is seen in the cartilaginous space between the interneural and interhæmal spines and their respective fins; a space occupied in the *Dapediidæ* and *Dorypteridæ,* by the basilar interneurals and interhæmals. This character is however not universal in the *Pycnodontidæ.* Prof. Agassiz speaks (Poissons Fossiles) of a maxillary bone, which bears a few teeth, in this family. This character will distinguish it at once from the *Plectognathi* and all other physoclystous orders. The abdominal position of the ventral fins and unmodified anterior vertebræ, indicate that these fishes may for the present be placed with the preceding, in the *Isospondyli.* There they are well distinguished by the peculiar inverted chevron-like bones which protect the dorsal and lateral regions in front of the dorsal fin. Prof. Agassiz describes the vertebræ of *Pycnodus* as osseous; M. Thiolliere figures some species as without osseous centra, a condition I have observed in some specimens.

The characters of the *Dorypteridæ* are, according to the very full description of Messrs. Hancock and Howse,† more strongly peculiar. Although these fishes may be referred to the *Physoclysti,* on account of the thoracic position of their ventral fins, they present features which will not permit a reference to any known order. It has been shown that they

*Description des Poiss. Foss. prov. d. l. Gisem. Jurass. d. le Bugey; premiere livr. Thiolliere et Gervais.

† Quarterly Journ. Geolog. Society, London, 1870, p. 623.

possess the basilar interneural bones, which as I have pointed out,* only exist in the *Physoclysti* in small development in the *Batrachidæ*; and occur in various degrees of development in some *Physostomi*, being especially elongate in the anal fin of *Amia*. It is even possible that another element enters into the series connecting the neural spines with the dorsal fin-rays. The pectoral fin possesses fourteen or fifteen basilar radial bones; a character which like the last, is not found in the *Plectognathi*; these fishes having but three or four such elements. These two points indicate a lower position than that of the latter order, and a relation to it similar to that which *Amia* bears to the *Isospondyli*. It goes to show that even among some of the earlier fishes, physoclystous characters were foreshadowed. I therefore establish a new order for its reception to take its place at the base of the line of Physoclysti.

As a résumé of the preceding inquiry, the following table of the families treated of, with their definitions, is now given:

Order ISOSPONDYLI.

Physostomous fishes with distinct parietal bones; unmodified anterior vertebræ; and three or four basilar bones of the pectoral fin. Symplectic and præcoracoid bones present so far as known.

Fam. SAUROPSIDÆ (*Sauroides* Agass. partim.)

Teeth of different sizes, the large raptorial ones mingled with small ones; vertebral column osseous; no basilar interneurals or interhæmals.

1. Caudal fin with many vertebræ; scales rhomboid;—*Pygopterus, Eugnathus.*
2. Caudal fin with few vertebræ; scales rhomboid;—*Pachycormus,*† *Sauropsis, Macrosemius, Belonostomus, Aspidorhynchus.*
3. Caudal fin with numerous vertebræ; scales rounded;—*Megalurus, Callopterus,*‡ *Attakeopsis.*‡
4. Caudal fin with few vertebræ (in some instances apparently none); scales rounded;—*Caturus, Leptolepis, Anædopogon,*§ *Thrissops.*

Fam. LEPIDOTIDÆ, (*Lepidoides* Agass. partim.)

Teeth simple, often obtuse, in one or many rows, without elongate ones intermixed; no basilar interneurals or interhæmals; vertebræ with the centra incompletely ossified;‖ (scales rhomboid; caudal fin vertebrated.) *Amblypterus, Palæoniscus, Eurynotus, Semionotus, Lepidotus, Pholidophorus, Microps, Notagogus, Ophiopsis, Cosmolepis, Pleuropholis.*

Fam. DAPEDIIDÆ mihi.

Teeth uniform, obtuse; vertebræ with incompletely ossified centra;‖ the interneural spines commencing at the head; a complete series of basilar interneural and interhæmal spines;¶ *Platysomus, Dapedius, Tetragonolepis.*

* Transac. Amer. Philos. Soc. 1871, XIV, p. 451.
† Vide *P. heterurus* and *P. macropterus* Ag.
‡ Thiolliere et Gervais Poissons Foss. de Bugey.
§ Cope, Proceedings American Philosophical Society, 1871, p. 53.
‖ These statements are derived from Agassiz, Poissons Fossiles.
¶ Agass. Poiss. Fossiles, II. Pl. D. fig. 2.

Fam. PYCNODONTIDÆ.

Teeth obtuse molar, covering the vomer and palatine bones; no basilar interneural and interhæmal bones; chevron-shaped bones protecting the dorsal region, their branches extending on the sides; abdomen protected by similar bones, which form plates on the median line; interneurals continued far forwards.—*Microdon, Pycnodus, Gyrodus, Mesodon.*

Order DOCOPTERI mihi.

Scapular arch suspended to the cranium; pectoral fin with numerous, (not more than fifteen known) basal radii; ventral fins thoracic. Dorsal and anal fins with basilar interneurals.

Fam. DORYPTERIDÆ.

Vertebral column osseous; caudal fin not or very shortly vertebrated. Interneural spines corresponding with the basilars on the abdominal, but not on the caudal parts of the vertebral column. Ribs complex, united with abdominal dermal bones which form a series of median plates.

None of the Isospondylous families above described possess the dental characters of the *Saurodontidæ*, i. e. the long fangs set in deep alveoli.

RHYNCHOCEPHALIA.

CLEPSYDROPS COLLETTII Cope, Proceedings Academy, Philadelphia, 1876, p. 407.

This species proves to be the most abundant land vertebrate of the formation. It is represented in all the collections, sometimes by portions of individuals of double the size of the types. I referred this genus to the *Rhynchocephalia* originally, although it possesses a few batrachian characters. The occipital condyles preserved in the present collection are simple and median, thus confirming the reference, were confirmation needed. A supposed sacral vertebra is free at both extremities, and presents on each side, just behind the articular extremity, a very large facet, extending from a rudimental diapophysis to the plane of the inferior surface of the centrum. The specific reference of this vertebra is not certain.

CLEPSYDROPS VINSLOVII Cope, sp. nov.

This species is represented by a third cervical vertebra; and probably by other centra, but in this one the characters distinguishing it from *C. collettii* are especially visible.

The inferior median line is a keel, some distance above it, the sides of the centrum are full, rising in a longitudinal angle. There is no constriction or fossa below the diapophysis as in *C. collettii*. The latter is anterior in position, is vertically compressed, and is curved forward for a short distance below. The posterior articular face is regularly funnel-shaped from the margin; the anterior face has a broad recurved lip. This passes round the inferior margin, which is not projected forwards as in *C. collettii*. The

zygapophyses are well developed, and stand close together. The neural spine is compressed, and the basal portion points somewhat forwards.

	M.
Length of centrum	.011
Diameter of posterior articular face { vertical	.009
Diameter of posterior articular face { transverse	.009
Vertical diameter of diapophysis	.006
Expanse of posterior zygapophysis	.009
Anteroposterior diameter of base of neural spine	.005
Transverse diameter of neural arch	.006

CLEPSYDROPS PEDUNCULATUS, sp. nov.

Established on two vertebræ obtained by Mr. Gurley, of a lizard of larger proportions than any of those belonging to the other species of the genus. One of these is a third cervical and the other is apparently a dorsal; both differ from corresponding vertebræ of *C. collettii* and of *C. lateralis* in having elongate diapophyses for the attachment of the ribs. These are present in the other species, but are either very short, or sessile. The third cervical has a broad reverted anterior lip-like margin of the anterior articular face, which resembles the corresponding part in *C. lateralis* in not being produced below. The median line is keeled, and there is a shallow longitudinal groove on the upper part of the sides. The posterior articular face is regularly funnel-shaped. The diapophyses are very stout, and are directed a little downwards and strongly backwards. The articular faces are single, look downwards and outwards, and are wide above, and narrow below. The base of the neural canal is deeply incised, as in the other species.

Diameter of centrum, { anteroposterior	.015
Diameter of centrum, { transverse	.0125
Diameter of centrum, { vertical	.0120
Length of diapophysis above	.009
Diameter of diapophysis { vertical	.008
Diameter of diapophysis { anteroposterior	.005

The dorsal vertebræ exhibits a longer and more slender diapophysis whose base is vertically expanded, and with a shallow fossa before and behind. The superior half of the diapophysis has a much greater anteroposterior extent than the inferior. There is no recurved rim of the articular extremities, but the surface does not pass regularly into the foramen chordæ dorsalis, but by an abrupt descent at its mouth. The sides of the centrum are concave, and the inferior portion forms a prominent rounded rib.

Diameter of centrum { anteroposterior	.016
Diameter of centrum { transverse	.015
Diameter of centrum { vertical	.016
Length of diapophysis	.009
Width af neural canal	.0065

CRICOTUS HETEROCLITUS Cope, Proceed. Acad. Phila. 1876, p. 405.

GENERAL OBSERVATIONS.

After an examination of the first fossils from this fauna which came under my observation, I left the question undecided as to whether its characters pointed to the Triassic or to Permian age. The *Reptilia* and a *Ceratodus* pointed to the former; the *Diplodus* pointed even to the coal measures. The additional evidence adduced in this paper, adds weight to both sides of the question. Of the fishes added, *Ctenodus* is a genus of the coal measures, and while *Strigilina* is new, its affinities are to the Petalodont genera of that formation. On the other hand the reptilian character of *Clepsydrops* is established, and the number of its species increased. Now the coal measures have nowhere disclosed reptilian remains, so far as we have determinations of a reliable character; *Batrachia* were the only type of air breathing vertebrata known to that epoch. The present fauna must then be placed above the coal measures, and the horizon will correspond more nearly with the Permian than with any other embraced in the system.

From its most characteristic fossil, the bed might be called the *Clepsydrops* shale. Its position, according to Dr. J. C. Winslow, is near the top of the Coal Measures, and it is marked No. 15, in Prof. F. H. Bradley's section of the Coal Measures of Vermillion Co., in the Report of the Geological Survey of Illinois by A. H. Worthen, Vol. IV, p. 245. It is about one hundred and eleven feet, averaging different localities, from the summit of the series, and 2099½ feet from the base. Two insignificant beds of coal occur above it, and the following genera of invertebrate fossils: *Productus, Spirifer, Athyris, Terebratula, Hemipronites, Retzia, Zeacrinus, Cyathaxonia, Discina, Lingula, Cardiomorpha, Orthoceras* and *Nautilus*. Several of these genera are found in the Zechstein, while others belong to the Coal Measures and below them.

On some new and little known Reptiles and Fishes from the Austroriparian Region.

BY E. D. COPE.

(*Read before the American Philosophical Society, May* 20, 1877.)

A number of interesting points in the distribution of our reptiles and fishes come to light from time to time, which serve to define with more precision the districts into which the Nearctic Realm is naturally divided.* The result of several of these, is to extend over the entire Austroriparian Region the range of several species heretofore supposed to be confined to portions of that district only. A collection formed at Kinston in Eastern North Carolina, in the North-eastern portion of the region in ques-

* See Bulletin No. 1 of the National Museum; Check List of North American Batrachia and Reptilia.

tion, by my friend, J. W. Milner, of the United States Fish Commission, is of considerable interest on this account. He found at that point the following species, which had not been previously known to occur east of Georgia or South Carolina:—Batrachia: *Manculus quadridigitatus, Bufo quercicus, Engystoma carolinense.* Reptilia: *Oligosoma laterale, Abastor erythrogrammus.* To this it may be added that Stephen G. Worth recently obtained near Fayetteville, North Carolina, the *Bascanium flagelliforme*, and the true *Hyla delitescens* of Holbrook. I here mention also that several years ago Dr. J. E. Holbrook sent me just before his death a colored drawing of a *Hyla* from S. E. Georgia, made by his friend Dr. Harden, which is probably the *H. carolinensis*, but which differs from the typical form of that species in having a white triangle on top of the muzzle, covering the space between its apex and a line connecting the anterior parts of the orbits, as in the *H. leucophyllata.* A specimen representing a variety of *Eumeces anthracinus* Baird, was sent me from Mobile by Dr. Jos. Corsoñ.

The researches of the distinguished ornithologist, Robert Ridgeway, into the natural history of South-eastern Illinois, have been followed by the same results as those of Mr. Milner in North Carolina. Mr. Ridgway has found in the Wabash valley as far North as Mount Carmel, Illinois, the following species: *Ancistrodon piscivorus, Carphophiops vermis, Haldea striatula, Abastor erythyogrammus, Farancia abacura, Coluber obsoletus confinis* and *Tropidonotus sipedon woodhousei.*

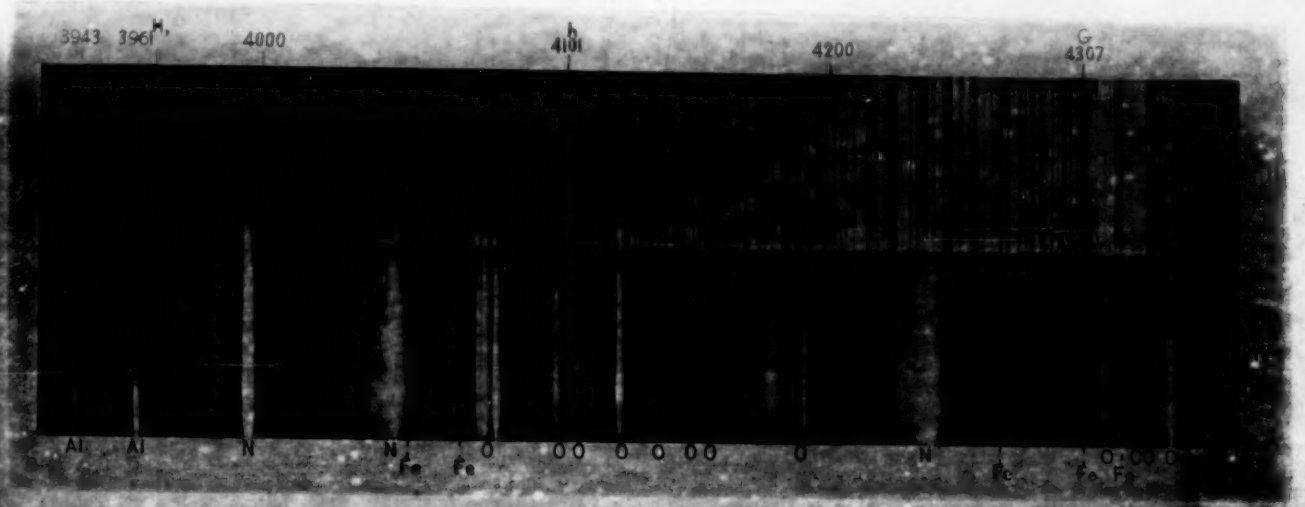
In a considerable collection from Volusia, Florida, several rare species occur. I give the entire list.

BATRACHIA.

Siren lacertina, L.
Pseudobranchus striatus, Lec.
Amphiuma means, Gard.
Engystoma carolinense, Daud.
Acris gryllus, Lec.
Hyla gratiosa, Lec.
" *carolinensis*, Daud.
" *femoralis*, Daud., very common.
Rana halecina Kaln.

REPTILIA.

Crotalus adamanteus, Beauv.
Caudisona miliaria, L.
Ancistrodon piscivorus, Latr.
Heterodon platyrhinus, Latr.
Tropidonotus fasciatus, L.
Eutænia sackenii, Kenn., very common.
" *sirtalis*, L.
Storeria occipitomaculata, Holbr.
Coluber quadrivittatus, Say.
Spilotes corais erebennus, Cope.
Bascanium constrictor, L.
" *flagelliforme*, Catesb.
Cyclophis æstivus, L., abundant.
Pityophis melanoleucus, Holbr.



DISCOVERY OF OXYGEN IN THE SUN BY PHOTOGRAPHY, BY PROFESSOR HENRY DRAPER, M. D. 1876.

The upper part of the photograph is the spectrum of the Sun, the lower part is the spectrum of the Oxygen and Nitrogen of Air. The letters and figures round the margin are printed with type on the negative; with this exception the photograph is absolutely free from hand work or retouching. O. indicates Oxygen, N. Nitrogen, Fe. Iron, Al. Aluminium. The figures above the Sun's spectrum are wave-lengths; G. h. H., are prominent Solar lines at the violet end of the spectrum. The principal point to examine is the coincidence of the bright Oxygen lines with bright lines in the Solar spectrum. The picture is printed from Dr. Draper's original negative by Bierstadt's Albertype process.

Dromicus flavilatus, Cope. The second specimen of this very rare species, comes from Volusia. The first was found by Dr. H. C. Yarrow, near Fort Macon, North Carolina.

Osceola elapsoidea, Holbr.

Contia pygæa, Cope. So far as yet known, found only near Volusia.

Cemophora coccinea, Blum., common.

Tantilla coronata, B. & G.

Rhineura floridana, Baird, abundant.

Oligosoma laterale, Say.

Eumeces striatus, L.

Cnemidophorus sexlineatus, Say.

Sceloporus undulatus, Harl.

Anolis principalis, L.

Alligator mississippiensis.

A collection of fishes from the same locality includes a number of interesting species, as follows:

Notemigonus ischanus, Jordan, Check List Fishes Fresh W., N. A. p. 155. A specimen eight inches in length with bright red dorsal, caudal and anal fins.

Arius ?equestris, Baird and Girard, U. S. and Mexican Boundary Surv. II p. 32.

Fine specimens of a species distinct from those of any other country from near Bayport, West Florida, agree in most of the characters cited by the above named authors. Their type was a young fish I suppose, in which the helmet had no such development as in my specimens; its beards are also rather longer.

Chirostoma beryllinum Cope, Trans. Amer. Phil. Soc. 1866, p. 403.

Prof. Jordan states that he has this fish from the St. John's R., Florida.

Haplochilus melanops Cope, Proc. Am. Philos. Soc. 1870, p. 457.

Chænobryttus gulosus C. V. *Centrarchus* C. V.

Radii; D. X-10; A. III-9. Depth of body entering total length 2.75 times.

Enneacanthus fasciatus Holbr. *Bryttus fasciatus* Holbr. Journ. Acad. Phila. 1855, p. 51, Pl. 5, fig. 3.

Char. specif. General form elongate, as in some of the *Chænobrytti*. The depth enters the total length with caudal fin, 3.2 times, and the length of the head enters the same 3.4 times. The diameter of the eye is twice as long as the muzzle, and enters the head 3.2 times, and exceeds the interorbital width. The extremity of the maxillary bone marks the line of the anterior fourth of the orbit. The profile is a gentle convexity from the base of the first dorsal ray. Scales 6–34–13; four rows below the eye on the preoperculum; opercle scaled.

Color a rich brown, with numerous vertical darker bars descending from the base of the dorsal fin. Scales below the middle of the sides each with a brown dot; fins dusky, the dorsal and caudal with pellucid dots. Superior

angle of the operculum with a black spot without border, no radii on the cheek ; nose black.

Total length	.055
Length to dorsal fin (axial)	.016
Length to anal fin (axial)	.025
Length to caudal fin (axial)	.044

Lepomis auritus Linn Jordan. *Ichthelis rubricauda* Holbrook.

Lepomis apiatus sp. nov.

A species of discoid form, possessing a well developed patch of teeth on the palatine bones. The gill rakers, although elongate on the anterior half of the first branchial arch are obtuse at their extremities ; they are quite robust, and become shorter on the inferior portion of the arch.

The depth of the body is contained in the total length (with caudal fin) 2.27 times, and the length of the head enters the same 3.3 times. The orbit is as wide as the length of the muzzle, and enters the length of the 4.25 times, and equals the inter-orbital width. The extremity of the maxillary bone reaches the vertical line marking the anterior two-fifths of the orbit.

The dorsal spines are robust and high, and are as long as the soft rays; The caudal fin is slightly emarginate. The ventral reaches the first and the pectoral the second anal spines. Radial formula ; D. X-11 ; A. III-10 ; P. 12. The opercular flap is short. Scale formula 6–44–12 ; six rows on the preoperculum below the eye. Opercle scaly.

Color, brown, dark above, lighter below. Each scale has a black spot at the base forming together longitudinal series ; these are less distinct on the superior half of the sides, and are obsolete in that region in large specimens. The spots are distinct on the opercular scales. Fins and muzzle black. Gill spot black, without border.

	M.
Total length	.168
Length to dorsal fin (axial)	.052
" ventral " "	.052
" anal " "	.082
" caudal " "	.140

The external series of teeth are relatively larger in this species than in the *L. auritus* and *L. mystacalis*. No teeth on the tongue.

Lepomis mystacalis, sp. nov.

In this species the gill rakers are of the character indicated by Prof. Jordan as characteristic of the genus *Lepomis*, that is, slender and acute. This species also differs from the *L. apiatus* in the greater compression, and the shorter muzzle.

The greatest depth enters the total length (including caudal fin) 2.5 times, and the length of the head enters the same 4.4 times. The orbit is large, exceeding the length of the muzzle, equaling the interorbital space, and entering the length of the head 3.3 times. Radial formula ; D. X-12 ; A. III-12 ; P. 12. The dorsal spines are robust, but a little shorter than

the soft rays; the ventral fin reaches the first spine, and the pectoral the first soft ray of the anal fin. Caudal well notched. The maxillary extends a little beyond the anterior border of the orbit. Scale formula 7–51–15; four preopercular rows below orbit.

Color above dusky, sides silvery, with numerous short undulate vertical brown bars irregularly disposed. Opercular black spot short, without border; the dusky of the face is abruptly arrested by a pale band which extends backwards from the mouth to the preoperculum. A dark line from the chin bounds this below, and defines another silvery band which passes along the mandible, the interopercle and subopercle; cheeks, thorax, and posterior parts of the dorsal, caudal and anal fins yellow.

Xystroplites longimanus, gen. et. sp. nov.

Char. Gen. Inferior pharyngeal bones wide and robust, and paved with truncate grinding teeth. The gill rakers of the anterior half of the first branchial arch elongate; those of the posterior half and of the remaining gill arches, very short and obtuse. No supernumerary maxillary bone; operculum with a produced, entire superior posterior angle. No teeth on the tongue. Spines X. III.

This genus which has been just published by Prof. D. S. Jordan,* combines the grinding type of pharnygeal teeth characteristic of *Pomotis*, with the slender gill rakers recently shown by Prof. Jordan† to be characteristic of the genus *Lepomis*.

Char Specif. Body elevated, but the head rather produced, so that the profile is oblique and nearly straight from the base of the dorsal fin. The depth of the body enters the total length 2.5 times, and the length of the head enters the same 3.6 times. The orbit is large, equaling the length of the muzzle, and entering the length of the head four times. The interorbital space is 1.5 times the diameter of the orbit. The muzzle is subconic, and the end of the maxillary bone reaches the line of the anterior margin of the orbit.

The dorsal fin is elevated, the spines equalling the soft rays and not separated from them by a notch. Caudal fin openly notched; ventral not reaching anal; the pectoral very long, reaching the line of the fifth anal soft ray. Formula; D. X–12; A. III–11; P. 13. Scale formula 7–44–15; five rows on the preoperculum below the orbit.

The color above is dusky, below silvery, the gular and thoracic region light yellow. The opercular black spot is short, and has a crimson border. Fins black, the caudal, anal and pectoral fins with yellow rays.

Total length.....	.170
Length to dorsal fin (axial).....	.047
" ventral " "	.053
" anal " "	.081
" caudal " "	.131

* Prof. Jordan defined this genus in a paper written some time before this one, and which is probably already printed.

†Proceedings Academy, Philadelphia 1877, p. 76.

This fish has a superficial resemblance to the *Lepomis mystacalis*. The ends of the long gill-rakers are obtuse, as in the *L. apiatus*. There are no palatine teeth. It resembles also in form and coloration the *Pomotis microlophus*, Gthr. (*P. speciosus*, Holbr.) from the St. John's River, Florida, a species which I have not seen. According to Dr. Holbrook's figures and descriptions, there is a material difference in the radial formula which is, D. X .10; A. III .9. The form of the dorsal fin is also very different, the second being the higher, and separated from the first by a deep notch, which leaves one spine with the soft rays.

I have this species from near Volusia, and also from near Bayport on the West Coast.

Achirus mollis, De Kay.

Radii, D. 48; A. 35. Length without caudal fin .078; depth of body .042.

CONTRIBUTIONS FROM THE LABORATORY OF THE UNIVERSITY OF PENNSYLVANIA.

No. X.

Dichlorsalicylic Acid.

By Edgar F. Smith, Ph. D.,

Assistant in Analytical Chemistry, University of Pennsylvania.

(*Read before the American Philosophical Society, June* 15, 1877.)

As early as 1845, Cahours (Annalen der Chemie und Pharmacie—52. pp. 340 and 341) described a di-chlor acid which he obtained about the same time he was investigating the di-bromine substitution products of salicylic acid.

The course he pursued to produce the compound was to treat an aqueous solution of salicylic acid with an excess of chlorine. According to his description the acid thus obtained possesses great stability and can very readily be obtained pure.

And again by allowing a slow current of chlorine gas to stream through a dilute solution of potassium salicylate potassium dichlorsalicylate was formed. This salt after repeated recrystallization was obtained in almost colorless needles.

The acid corresponding to this salt was precipitated in white masses upon the addition of dilute hydrochloric acid to a solution of the latter. The acid is soluble in boiling alcohol, from which upon cooling, it separates in needles. Well formed octahedral crystals were secured by allowing a rather dilute solution to evaporate slowly in the air. Boiling water dissolves but small quantities of this acid, which separate out again in very fine needles when the solution becomes cool. Boiling concentrated nitric acid dissolves the compound, and when the liquid cools, beautiful yellow

plates separate out. By distilling the acid with barium oxide dichlorphenol (Acide Chlorophénèsique) was produced, with liberation of carbon dioxide.

Recently, Rogers (Inaugural Dissertation, Göttingen, 1875) published the results of an investigation upon a similar acid. By conducting a calculated amount of chlorine gas into a solution of salicylic acid in glacial acetic acid, and applying heat, he produced dichlorsalicylic acid, which crystallized from the above solution in small white needles. The acid was purified by converting it into its barium salt, and this then recrystallized. The acid from the purified salt fused at 224°C. It was entirely insoluble in cold, soluble in an excess of hot water and very soluble in hot alcohol.

The following salts were made and analyzed :

Dichlorsalicylate of Barium.—$(C_6\ H_2\ Cl_2\ OH\ COO)_2\ Ba + 5\ H_2O$. Long needles, colored slightly brown.

Dichlorsalicylate of Potassium.—$C_6\ H_2\ Cl_2\ OH.\ C\ O\ O\ K$. Showed a tendency to crystallize in small white needles, which lost, by exposure to the air, any water of crystallization they may have possessed.

Dichlorsalicylate of Copper.—$(C_6\ H_2\ Cl_2\ OH\ C\ O\ O)_2\ Cu$. Green, insoluble precipitate.

Some time ago I had occasion to make dichlorsalicylic acid, but as I obtained a compound not corresponding to any known analogous derivative, I submit to the Society the following results of my investigation upon the new dichlorine product.

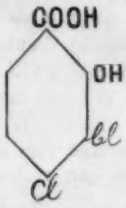
Formation of Dichlorsalicylic Acid.

About 40 Grm. of pure salicylic acid (fusing point 156°C) were placed in a flask and upon this was poured a rather large quantity of concentrated acetic acid. While applying a gentle heat to effect solution, a calculated amount of dried chlorine gas was introduced into the liquid, which gradually assumed a deep yellow color. Without waiting for the new acid to crystallize out I added to the yet warm solution a large quantity of water, whereupon the dichlorsalicylic acid fell out in large white flocks. The liquid was filtered off and the acid washed with cold water and then boiled with an excess of barium carbonate. The salt thus obtained was redissolved and recrystallized until it was obtained in almost colorless needles, which crystallize in aggregated masses from an aqueous solution. Upon several occasions monochlorsalicylate of barium was produced, but as this salt is much more soluble than the corresponding compound of the dichlor acid it was easily removed.

Properties —The dichlor acid separates in large flocculent masses upon the addition of dilute hydrochloric acid to a solution of the barium salt. Cold water does not dissolve the acid, an excess of boiling water being necessary to effect its solution. After many recrystallizations the acid fused at 212°–214°C. It separates from an aqueous solution in white arborescent masses. In cold alcohol it is very soluble. By the slow evaporation of such a solution stellated masses consisting of large colorless needles were obtained. The fusing point of these was the same as that of the white

crystals. The acid is sublimable with partial decomposition. A drop of ferric chloride added to its aqueous solution imparts to the latter a beautiful violet coloration.

The acid is very probably Parachlormetachlor-ortho-oxybenzoic acid and may be graphically represented as follows:



A combustion was made of the barium salt.

Carbon and Hydrogen Determination. 0.2092 Grm. barium salt dried at 180°C for several hours were burned with coarse and fine lead chromate, and gave 0.241 Grm. CO_2=.065 Grm. carbon = 30.9% C. Farther .012 Grm. H_2O=0.57% H.

SALTS.

Dichlorsalicylate of Barium.

$$(C_6 H_2 Cl_2 OH COO)_2 Ba + 3\tfrac{1}{2} H_2O.$$

This salt was produced by boiling the free acid with an excess of barium carbonate. Boiling water dissolves it very readily. In cold water it is insoluble. From an aqueous solution it crystallizes in large, almost colorless needles, which are usually combined to aggregated masses.

Water Estimation.

0.6026 Grm. air-dried salt lost upon being heated for three hours at 180° C .0623 Grm. H_2O=10.34% H_2O.

The calculated percentage of water for $3\frac{1}{2}$ molecules equals 10.29%.

	Calculated.	Found.
$(C_6 H_2 Cl_2 OH COO)_2 Ba$	= 551 = 89.71%.	
$+3\frac{1}{2} H_2O$	= 63 = 10.29%.	10.34
	614 = 100.00%.	

Barium Estimation.

I. 0.5403 Grm. anhydrous salt were placed in a platinum crucible, a few drops of sulphuric acid then added, and this then evaporated to dryness. 0.2227 Grm. barium sulphate were obtained, corresponding to 0.1309 Grm. barium=24.16% Ba.

II. 0.6075 Grm. anhydrous salt gave 0.2550 Grm. barium sulphate, equaling 0.1499 Grm. barium=24.67% Ba.

Calculated %.	Found %.
C_{14}=168=30.60	30.90
H_6= 6= 1.09	.57
O_8= 96=18.60	
Cl_4=142=25.86	
Ba=137=24.95	24.16 and 24.67

DICHLORSALICYLATE OF POTASSIUM.

$$C_6 H_2 Cl_2 OH C O O K.$$

This salt was obtained by boiling the preceding compound with a calculated amount of potassium carbonate. From a concentrated aqueous solution it crystallized in white needles, very much like the salt of Rogers described above. After recrystallizing the compound several times and then allowing it to separate from a dilute solution I obtained it in almost colorless needles, that united to form clusters.

Analysis proved it to be anhydrous.

Potassium Estimation.

I. 0. 2020 Grm. well dried salt gave 0.0710 Grm. potassium sulphate= .03181 K=15.75% K.

II. .2651 Grm. dried salt gave .0930 Grm. potassium sulphate=0.04117 Grm. K=15.5% K.

	Calculated %.	Found %
$C_6 H_2 Cl_2 OH COO$	=206=84.05%	
+ K	=39.1=15.95%	15.75% and 15.5%
	245.1=100.00	

DICHLORSALICYLATE OF SODIUM.

$$C_6 H_2 Cl_2 OH COO Na.$$

Obtained by boiling an aqueous solution of the barium salt with sodium carbonate and concentrating the filtered liquid. The salt crystallizes in broad needles, possessing a slight yellow tinge. It is easily soluble in water.

Sodium Estimation.

0.1601 Grm. dried salt gave 0.0530 Grm. sodium sulphate=.0171 Grm. sodium=10.68% Na.

	Calculated %.	Found %.
$C_6 H_2 Cl_2 OH COO$	=207=89.95%	
+ Na	= 23=10.05%	10.68%
	229=10000%	

DICHLORSALICYLATE OF MAGNESIUM.

$$(C_6 H_2 Cl_2 OH COO)_2 Mg.$$

An aqueous solution of the free acid was boiled with magnesium carbonate and the liquid evaporated to a small bulk. After standing some time, small, white crystals appeared; these were very readily dissolved by water.

Magnesium Estimation.

.1140 Grm. dried salt gave .0304 $Mg_2 P_2 O_7$=.0064 Grm. Mg=5.61% Mg.

	Calculated %.	Found %.
$(C_6 H_2 Cl_2 OH COO)2$	=412=94.50%	
+ Mg	= 24= 5.50%	5 61%
	436=100.00	

Dichlorsalicylate of Lead.

$C_6 H_2 Cl_2 O Pb C O O.$

Lead acetate was added to a solution of the ammonium salt and the lead salt obtained as a white insoluble precipitate, which after being well washed and dried was analyzed.

Lead Estimation.

0.1075 grm. dried salt gave .0548 grm. lead = 50. 9 % Pb.

Calulated %.		Found %
$C_6 H_2 Cl_2 O.$	$C O O = 205 = 49.76$ %	
	$+ Pb = 207 = 50.24$ %	50. 9 %
	$412 = 100.00$ %	

Copper Salt.—Small brown crystals soluble in water.

Silver Salt.—White insoluble powder. Decomposed when boiled with water.

Action of Nitric Acid upon Dichlorsalicylic Acid.

Dilute nitric acid has no effect upon the acid. When treated with fuming nitric acid no change is produced until heat has been applied. After dissolving the dichlor acid in this solvent I permitted the solution to stand several days, hoping to find the nitro compound separated out by that time—this, however, did not occur. Upon evaporating the solution to dryness, nothing remained, the substance, whatever it may have been, having been completely volatilized. A second portion of the acid after treatment with fuming, nitric was mixed with a large quantity of water and then distilled. The distillate possessed a yellow color, and after neutralization with potassium carbonate, was strongly evaporated, then placed in a dessicator over sulphuric acid. After standing some time minute globular crystals appeared, but the quantity being so small I was not able to examine them, preferring to defer the investigation of this nitro compound, if such, until larger quantities of the substance can be obtained.

Calcium Oxide and Dichlorsalicylic Acid.

The acid distilled with calcium oxide yielded an almost colorless oil, having a rather pungent odor. The compound was not further examined.

Ethyl Dichlorsalicylate.

$C_6 H_2 Cl_2 OH C O O. C_2 H_5.$

The introduction of the ethyl radical was first attempted by heating upon a water bath a small flask containing the silver dichlorsalicylate and ethyl iodide. This, however, failed to produce the desired result.

In a second trial the perfectly dry and pulverized silver salt was placed in a tube of Bohemian glass, an excess of ethyl iodide then added, the tube sealed and heated in an air bath for twelve hours, the temperature not exceeding 135°C. Upon examination a rather large quantity of silver iodide was noticed, and the liquid which before heating was colorless was now of a reddish-brown hue. The tube was opened and its liquid contents poured

through a small filter and after washing the silver iodide with alcohol, the filtrate was evaporated upon a water bath. When the liquid had almost approached dryness I observed minute oil globules of a dark color.

The evaporating dish containing these was immediately removed from the water bath and stood in a cool place. In course of a few hours the oil solidified to a dark crystalline mass, which after pressing well between sheets of filter paper, I dissolved in alcohol and after concentration allowed to cool. Beautiful colorless needles separated from the solution. The fusing point was found to be 47°C. Again dissolved and allowed to crystallize the same form of crystals was obtained. The fusing point remained the same.

Carbon and Hydrogen Estimation.

0.2072 Grm. well dried substance, burned with lead chromate gave .3418 Grm. CO_2 45.51 % carbon. And .0808 Grm. H_2O = 4.30 % hydrogen.

Calculated %		Found %
C_9 = 108	= 45.96 %	45.51 %
H_8 = 8	= 3.40 %	4.30 %
Cl_2 = 78	= 30.21 %	
O_3 = 48	= 20.42 %	

Cahours* obtained a similar compound by the action of chlorine upon ethyl-salicylate. Broad colorless, shining needles. Fusing point not given. Potassium ethyl-dichlorsalicylate.

$$C_6\ H_2\ Cl_2\ OK\ C\ O\ O\ C_2\ H_5.$$

This salt was produced by boiling an alcoholic solution of the ether with potassium carbonate. It crystallizes in fine colorless needles, which frequently are united to bundles. Very soluble in alcohol.

The points of difference between the compounds of Cahours, Rogers and myself are in brief these :

The acid of Cahours is but slightly soluble in boiling water. Soluble in boiling alcohol, crystallizing from this in needles and octahedral crystals, and it forms also an insoluble nitro-derivative.

The acid gotten by me is perfectly soluble in boiling water, and in cold alcohol—crystallizing from the former in arborescent masses and from the latter it separates in large colorless needles. The nitro-derivative, if any, is exceedingly soluble.

The acid of Rogers fuses at 224°C, is soluble in boiling water and boiling alcohol. The barium salt has five molecules of water and the copper salt is a green insoluble precipitate.

The acid obtained by me fuses at 212°–214°C, its barium salt has but three and half molecules of water and the copper salt forms dark brown warty crystals, soluble in boiling water.

* Annalen d. Chemie u. Phar. 73. 313.

Discovery of Oxygen in the Sun by Photography, and a new Theory of the Solar Spectrum.

By Professor Henry Draper, M. D.

(*Read before the American Philosophical Society, July* 20, 1877).

I propose in this preliminary paper to indicate the means by which I have discovered Oxygen and probably Nitrogen in the Sun, and also to present a new view of the constitution of the Solar Spectrum.

Oxygen discloses itself by bright lines or bands in the Solar Spectrum and does not give dark absorption lines like the metals. We must therefore change our theory of the Solar Spectrum and no longer regard it merely as a continuous spectrum with certain rays absorbed by a layer of ignited metallic vapors, but as having also bright lines and bands superposed on the background of continuous spectrum. Such a conception not only opens the way to the discovery of others of the non-metals, sulphur, phosphorus, selenium, chlorine, bromine, iodine, fluorine, carbon, &c., but also may account for some of the so-called dark lines, by regarding them as intervals between bright lines.

It must be distinctly understood that in speaking of the Solar Spectrum here, I do not mean the spectrum of any limited area upon the disc or margin of the Sun, but the spectrum of light from the whole disc. I have not used an image of the Sun upon the slit of the spectroscope, but have employed the beam reflected from the flat mirror of the heliostat without any condenser.

In support of the above assertions the accompanying photograph of the Solar spectrum with a comparison spectrum of Air, and also with some of the lines of Iron and Aluminium is introduced. The photograph itself is absolutely free from handwork or retouching. It is difficult to bring out in a single photograph the best points of these various substances, and I have therefore selected from the collection of original negatives that one which shows the Oxygen coincidences most plainly. There are so many variables among the conditions which conspire for the production of a spectrum that many photographs must be taken to exhaust the best combinations. The pressure of the gas, the strength of the original current, the number of Leyden jars, the separation and nature of the terminals, the number of sparks per minute, and the duration of the interruption in each spark, are examples of these variables.

In the photograph the upper spectrum is that of the Sun, and above it are the wave-lengths of some of the lines to serve as reference numbers. The wave-lengths used in this paper have been taken partly from Angström and partly from my photograph of the diffraction spectrum published in 1872. The lower spectrum is that of the open air Leyden spark, the terminals being one of Iron and the other of Aluminium. I have photographed Oxygen, Nitrogen, Hydrogen and Carbonic Acid as well as other

gases in Plücker's tubes and also in an apparatus in which the pressure could be varied, but for the present illustration, the open air spark was, all things considered, best. By other arrangements the Nitrogen lines can readily be made as sharp as the Oxygen are here, and the Iron lines may be increased in number and distinctness. For the metals the electric arc gives the best photographic results, as Lockyer has so well shown, but as my object was only to prove by the Iron lines that the spectra had not shifted laterally past one another, those that are here shown at 4325. 4307. 4271. 4063. 4045. suffice. In the original collodion negative many more can be seen. Below the lower spectrum are the symbols for Oxygen, Nitrogen, Iron and Aluminium.

No close observation is needed to demonstrate to even the most casual observer that the Oxygen lines are found in the Sun as bright lines, while the Iron lines have dark representatives. The bright Iron line at G (4307), on account of the intentional overlapping of the two spectra, can be seen passing up into the dark absorption line in the Sun. At the same time the quadruple Oxygen line between 4345 and 4350 coincides exactly with the bright group in the Solar Spectrum above. This Oxygen group alone is almost sufficient to prove the presence of Oxygen in the Sun, for not only does each of the four components have a representative in the Solar spectrum, but the relative strength and the general aspect of the lines in each case is similar. I do not think that in comparisons of the spectra of the elements and Sun, enough stress has been laid on the general appearance of lines apart from their mere position; in photographic representations this point is very prominent. The fine double line at 4319. 4317. is plainly represented in the Sun. Again there is a remarkable coincidence in the double line at 4190. 4184. The line at 4133 is very distinctly marked. The strongest Oxygen line is the triple one at 4076. 4072. 4069., and here again a fine coincidence is seen though the air spectrum seems proportionately stronger than the solar. But it must be remembered that the Solar spectrum has suffered from the transmission through our atmosphere, and this effect is plainest in the absorption at the ultra-violet and violet regions of the spectrum. From some experiments I made in the Summer of 1873, it appeared that this local absorption is so great, when a maximum thickness of air intervenes, that the exposure necessary to obtain the ultra-violet spectrum at sunset was two hundred times as long as at mid-day. I was at that time seeking for atmospheric lines above H like those at the red end of the spectrum, but it turned out that the absorptive action at the more refrangible end is a progressive enfeebling as if a wedge of neutral tinted glass were being drawn lengthwise along the spectrum towards the less refrangible end.

I shall not attempt at this time to give a complete list of the Oxygen lines with their wave lengths accurately determined, and it will be noticed that some lines in the air spectrum which have bright analogues in the sun are not marked with the symbol of Oxygen. This is because there has not yet been an opportunity to make the necessary detailed com-

parisons. In order to be certain that a line belongs to Oxygen, I have compared, under various pressures, the spectra of Air, Oxygen, Nitrogen, Carbonic Acid, Carburetted Hydrogen, Hydrogen and Cyanogen. Where these gases were in Plücker's tubes a double series of photographs has been needed, one set taken with, and the other without Leyden jars.

As to the spectrum of Nitrogen and the existence of this element in the sun there is not yet certainty. Nevertheless, even by comparing the diffused Nitrogen lines of this particular photograph, in which Nitrogen has been sacrificed to get the best effect for Oxygen, the character of the evidence appears. The triple band between 4240. 4227. if traced upward into the Sun has approximate representatives. Again at 4041. the same thing is seen, the solar bright line being especially marked. In another photograph the heavy line at 3995. which in this picture is opposite an insufficiently exposed part of the Solar Spectrum shows a comparison band in the Sun.

The reason I did not use air in an exhausted Plücker's tube for the production of a photograph to illustrate this paper, and thus get both Oxygen and Nitrogen lines well defined at the same time, was partly because a brighter light can be obtained with the open air spark on account of the stronger current that can be used. This permits the slit to be more closed and of course gives a sharper picture. Besides the open air spark enabled me to employ an iron terminal, and thus avoid any error arising from accidental displacement of the reference spectrum. In Plücker's tubes with a Leyden spark the Nitrogen lines are as plain as those of Oxygen here. As far as I have seen Oxygen does not exhibit the change in the character of its lines that is so remarkable in Hydrogen under the influence of pressure as shown by Frankland and Lockyer.

The bright lines of Oxygen in the spectrum of the solar disc have not been hitherto perceived probably from the fact that in eye observation bright lines on a less bright background do not make the impression on the mind that dark lines do. When attention is called to their presence they are readily enough seen, even without the aid of a reference spectrum. The photograph, however, brings them into a greater prominence. From purely theoretical considerations derived from terrestrial chemistry, and the nebular hypothesis, the presence of Oxygen in the sun might have been strongly suspected, for this element is currently stated to form eight-ninths of the water of the globe, one-third of the crust of the earth, and one-fifth of the air, and should therefore probably be a large constituent of every member of the solar system. On the other hand the discovery of Oxygen and probably other non-metals in the Sun gives increased strength to the nebular hypothesis, because to many persons the absence of this important group has presented a considerable difficulty.

At first sight it seems rather difficult to believe that an ignited gas in the solar envelope should not be indicated by dark lines in the solar spectrum, and should appear not to act under the law "a gas when ignited absorbs rays of the same refrangibility as those it emits." But in fact the sub-

stances hitherto investigated in the sun are really metallic vapors, Hydrogen probably coming under that rule. The non-metals obviously may behave differently. It is easy to speculate on the causes of such behavior, and it may be suggested that the reason of the non-appearance of a dark line may be that the intensity of the light from a great thickness of ignited Oxygen overpowers the effect of the photosphere just as if a person were to look at a candle flame through a yard thickness of ignited sodium vapor he would only see bright sodium lines, and no dark absorption lines. Of course, such an explanation would necessitate the hypothesis that ignited gases such as Oxygen give forth a relatively large proportion of the solar light. In the outburst of *T Coronæ* Huggins showed that Hydrogen could give bright lines on a background of spectrum analogous to that of the Sun.

However all that may be, I have no doubt of the existence of substances other than Oxygen in the Sun which are only indicated by bright lines. Attention may be called to the bright bands near G, from wave lengths 4307 to 4337, which are only partly accounted for by Oxygen. Farther investigation in the direction I have thus far pursued will lead to the discovery of other elements in the Sun, but it is not proper to conceal the principle on which such researches are to be conducted for the sake of personal advantage. It is also probable that this research may furnish the key to the enigma of the D_3 or Helium line, and the 1474 K or Corona line. The case of the D_3 line strengthens the argument in favor of the apparent exemption of certain substances from the common law of the relation of emission and absorption, for while there can be no doubt of the existence of an ignited gas in the chromosphere giving this line, there is no corresponding dark line in the spectrum of the solar disc.

In thus extending the number of elements found in the Sun we also increase the field of inquiry as to the phenomena of dissociation and recomposition. Oxygen especially from its relation to the metals may readily form compounds in the upper regions of the solar atmosphere which can give banded or channeled spectra. This subject requires careful investigation. The diffused and reflected light of the outer corona could be caused by such bodies cooled below the self luminous point.

This research has proved to be more tedious and difficult than would be supposed because so many conditions must conspire to produce a good photograph. There must be a uniform prime moving engine of two horse power, a dynamo-electric machine thoroughly adjusted, a large Ruhmkorff coil with its Foucault break in the best order, a battery of Leyden jars carefully proportioned to the Plücker's tube in use, a heliostat which of course involves clear sunshine, an optical train of slit, prisms, lenses and camera well focussed, and in addition to all this a photographic laboratory in such complete condition that wet sensitive plates can be prepared which will bear an exposure of fifteen minutes and a prolonged development. It has been difficult to keep the Plücker's tubes in order; often before the first exposure of a tube was over the tube was ruined by the strong Leyden sparks. Moreover, to procure tubes of known contents is troublesome. For

example, my hydrogen tubes gave a spectrum photograph of fifteen lines of which only three belonged to hydrogen. In order to be sure that none of these were new hydrogen lines it was necessary to try tubes of various makers, to prepare pure hydrogen and employ that, to examine the spectrum of water, and finally to resort to comparison with the Sun.

The object in view in 1873, at the commencement of this research was to secure the means of interpreting the photographs of the spectra of stars and other heavenly bodies obtained with my 28 inch reflector. It soon appeared that the spectra of Nitrogen and other gases in Plücker's tubes could be photographed and at first some pictures of Hydrogen, Carbonic Acid and Nitrogen were made because these gases seemed to be of greatest astronomical importance on account of their relation to stars, nebulæ and comets. Before the subject of comparison spectra of the Sun was carefully examined there was some confusion in the results, but by using Hydrogen the source of these errors was found out.

But in attempting to make a prolonged research in this direction, it soon appeared that it was essential to be able to control the electrical current with precision both as to quantity and intensity, and moreover, to have currents which when once adjusted would remain constant for hours together. These conditions are almost impossible to attain with any form of battery, but on the contrary are readily satisfied by dynamo-electric machines. Accordingly, I sought for a suitable dynamo-electric machine and motor to drive it, and after many delays procured a combination which is entirely satisfactory. I must here acknowledge my obligations for the successful issue of this search to Professor George F. Barker, who was the first person in America to procure a Gramme machine. He was also the first to use a Brayton engine to drive a Gramme.

The dynamo-electric machine selected is one of Gramme's patent, made in Paris, and is a double light machine, that is it has two sets of brushes, and is wound with wire of such a size as to give a current of sufficient intensity for my purposes. It is nominally a 350 candle light machine, but the current varies in proportion to the rate of rotation, and I have also modified it by changing the interior connections. The machine can produce as a maximum a light equal to 500 standard candles, or by slowing the rotation of the bobbin the current may be made as feeble as that of the weakest battery. In practical use it is sometimes doing the work of more than 50 large Grove nitric acid cells, and sometimes the work of a single Smee.

The Gramme machine could not be used to work an induction coil when it first reached me, because when the whole current was sent through the Foucault interruptor of the Ruhmkorff coil, making 1000 breaks per minute, the electro-magnets of the Gramme did not become sufficiently magnetized to give an appreciable current. But by dividing the current so that one pair of the metallic brushes, which collect from the revolving bobbin, supplied the electro-magnets, the other pair could be used for exterior work, no matter whether interrupted or constant. The current obtained in this

way from one pair of brushes when the Gramme bobbin is making 1200 revolutions per minute is equal to 100 candles, and is greater in quantity and intensity than one would like to send through a valuable induction coil. I usually run the bobbin at 622 revolutions per minute, and this rate will readily give 1000 ten-inch sparks per minute with the 18 inch coil. Of course a Plücker's tube lights up very vividly and generally, in order to get the maximum effect I arrange the current so that the aluminium terminals are on the point of melting. The glass, particularly in the capillary part often gets so hot as to char paper. The general appearance of the machine is shown in Fig. 1.

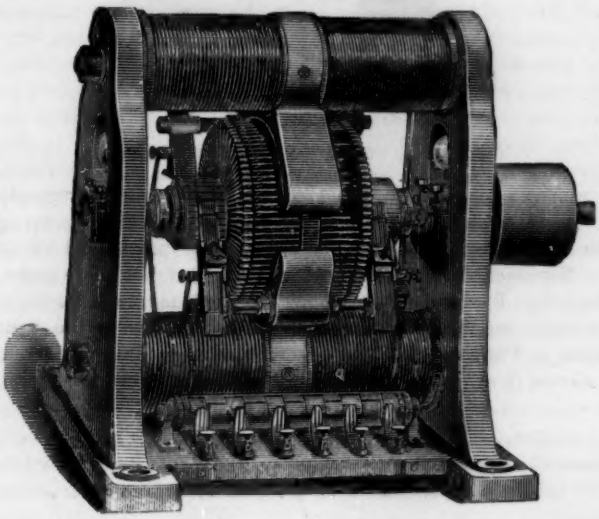


FIG. 1.—THE GRAMME MACHINE.

As long as the Gramme bobbin is driven at a steady rate the current seems to be perfectly constant, but variations of speed make marked differences in the current and this is especially to be avoided when one is so near the limit of endurance of Plücker's tubes. A reliable and constant motor is therefore of prime importance for these purposes. A difference of one per cent. in the speed of the engine sometimes cannot be tolerated, and yet at another time, one must have the power of increasing and diminishing the rate through wide limits. The only motor, among many I have examined and tried, that is perfectly satisfactory, is Brayton's Petroleum Ready Motor.

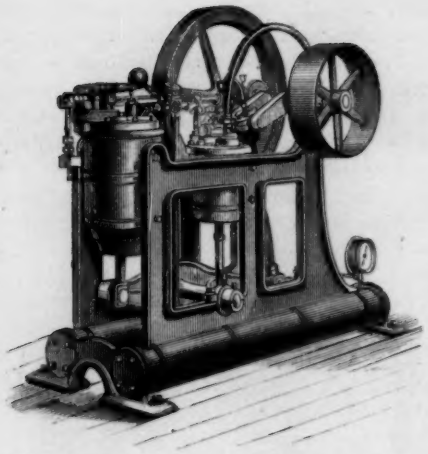


FIG. 2.—BRAYTON'S PETROLEUM MOTOR.

This remarkable and admirable engine acts like an instrument of precision. It can be started with a match and comes to its regular speed in less than a minute; it preserves its rate entirely unchanged for hours together. Moreover, it is economical, cleanly, and not more noisy than a steam engine. The one of two horse power I have, ran for six months, day and night, supplying water and air to the aquaria in the Centennial Exhibition at Philadelphia. At any time on going into the laboratory it can be started in a few seconds even though it has not been running for days.

Henry Draper's Observatory,
Hastings-on-Hudson, New York.

Note on the Exactitude of the French Normal Fork; a Reply to the paper of Mr. A. J. Ellis; by RUDOLPH KÖNIG, Ph. D.

(*Communicated by Professor Barker to the American Philosophical Society, July* 20, 1877.)

An attack, as strange as it was unexpected, has just been made in England upon the exactitude of the official French fork. Mr. Alexander J. Ellis, having found that the notes of a tonometer, composed of sixty-five harmonium reeds, constructed by Mr. Appunn, do not agree with this fork, has considered himself entitled to assert, in a paper published in the Journal of the Society of Arts (May 25, 1877), and in Nature (May 31, 1877) that the normal French fork La_3 gives, not 870 single vibrations, as has been hitherto supposed, but 878 single vibrations. Mr. Ellis, having established the further fact that the forks constructed by me are in perfect

accord with the French La_3, does not hesitate to affirm that all these forks, including those even of my large tonometer, which he has probably never examined, are necessarily inexact. Not having at my disposal the instrument used by Mr. Ellis, I confess that I find myself under some embarassment in stating at once by what error of construction this instrument, in the hands of Mr. Ellis, has given results so extraordinary. Fortunately, I can refer to a letter from M. Helmholtz addressed to Mr. Appunn and published by the latter himself in a paper on the acoustic theories of M. Helmholtz. This letter speaks of an instrument of exactly the same character, and made by the same maker, and sufficiently explains the surprising discoveries of Mr. Ellis. "I have examined your tonometer several times," writes M. Helmholtz to Mr. Appunn, "and I am astonished at the constancy of its indications. I would not have believed that reeds could give sounds so constant as those given by your apparatus, thanks to your method of regulating the current of air. The instrument, it is true, varies a little with the temperature, as do also forks; and hence it can be used for determining the absolute number of vibrations, only when one can work in a room heated by a stove. By the aid of an astronomical chronometer, I have counted the beats, and believe that your seconds pendulum must have been slightly inexact, because, though the number of beats agree very well among themselves, the absolute number obtained is not 240 but 237 to the minute. The temperature, which was rather low during my experiments, may count for something; but even this influence may be eliminated by counting the beats to the end of a major-third, which took me a quarter of an hour. In this way I have found for my Paris fork 435.01 vibrations, which agrees to the $\frac{1}{40000}$ nearly with the official number, 435 vibrations."

This letter proves that the entire number of beats in the octave of the tonometer tested by M. Helmholtz was $\frac{237}{60} \times 64 = 252.8$, and that its fundamental note was 505.6 single vibrations instead of 512. On comparing this note of 505.6 single vibrations with a fork giving actually 512 single vibrations, Mr. Ellis would find the latter to be 6.4 single vibrations more acute and, without doubt, would consider it as giving 518.4 single vibrations. Now for my forks giving 512 single vibrations, he has found 516.7 only, with the tonometer which he used. Whence it would seem that the fundamental note of this latter instrument had become more nearly exact than that of the tonometer examined by M. Helmholtz, since the number of its vibrations is 507.3. This note, however, still remains quite distant from its true value.

The fact that M. Helmholtz succeeded, with an instrument of this sort (and one too, even less perfect than that used by Mr. Ellis) in finding the number of vibrations of the official French fork to be exact, by first determining the correction needed for his instrument, is evidence that Mr. Ellis has neglected to determine a similar correction required for his tonometer. He has too hastily declared that these small tonometers with harmonium reeds are the most perfect and the most exact in existence. It would cer-

tainly have been much better if he had first given himself a little practice in the manipulation of acoustic instruments, before having treated so slightingly the results obtained by Lissajous, by Despretz, by Helmholtz, by Mayer, etc., etc., and before seeking to throw discredit upon the labors of a *constructeur* who had no reason to expect so unjustifiable an attack.

In addition to Helmholtz's evidence, Professor A. M. Mayer has furnished the following statement concerning the absolute number of vibrations of König's forks. "During the months of March, April and May of 1876, I made many determinations of the number of vibrations of König's UT_3 fork and found that it gave 255.96 complete vibrations in one second at a temperature of 60° Fahr. The following are the separate determinations of that series of which the above number is the mean: (1) 255.95, (2) 255.97, (3) 255.90, (4) 255.92, (5) 256.02, (6) 256.02. The forks vibratory period is accelerated or diminished $\frac{1}{21000}$ part by a difference of temperature of $\pm 1°$ Fahr."

26 Rue de Pontoise, Paris, June 5th, 1877.

On a New Species of Adocidæ from the Tertiary of Georgia.

By E. D. Cope.

(*Read before the American Philosophical Society, July* 20, 1877.)

Professor George Little, State Geologist of Georgia, placed in my hands for determination a Chelonite from a Tertiary formation in Macon Co. of that State. The matrix is a rather soft limestone of a light drab color. When the specimen was first obtained it was nearly perfect, lacking only the posterior part of one side, and the posterior border of the carapace. Having been mutilated by destructive curiosity hunters, there remain now the plastron and the anterior half of the carapace, with a considerable portion of the posterior part of the left margin. The surface has been exposed to the weather so as to obscure, and in some places to obliterate the dermal sutures, while the skeletal sutures are distinct. The form has been slightly distorted by lateral pressure, but not much.

The obscurity of the dermal sutures renders the determination of the generic affinities somewhat difficult. The skeleton preserves the Emydoid type, not exhibiting intersternal bones, and having a well developed mesosternum. The vertebral bones extend to between the sixth pair of costals, beyond which the specimen is imperfect in that region. The costal capitula are well developed, but whether they reach the vertebral centra, the specimen does not permit me to discover. The plastron is of peculiar form, the lobes being short and contracted. The anterior is rounded from a base of usual width, while the posterior, from a similar base, narrows rapidly to a point, as in the genus *Aromochelys*.

An important point is observed in the direction of the abdomino-pectoral

dermal suture. At its lateral extremities instead of continuing to the marginal scuta as in Emydoid genera, it turns forward and terminates at the inguinal notch, as in genera with intermarginal plates, as *Adocus* and *Dermatemys*. But the sutures of the intermarginals in the specimen are, if they ever existed, very obscure, owing to exposure to the weather. Nevertheless there is sufficient indication of them on one side, to render it tolerably safe to infer their existence. Anterior to the abdomino-pectoral suture, the border of the plastron is crossed by emarginations representing three scutal sutures, defining the humeral, gular, and intergular scuta. The courses of these sutures across the plastron are obscure. The humero-pectoral suture commences on the margin just in front of the axilla and extends forwards parallel with the border, becoming a deep open groove, which is apparent on both sides of the plastron. It then turns backwards, and appears to cross the plastron behind the mesosternum, presenting a concavity forwards. The next suture in front appears to cross near the middle of the mesosternal bone, presenting a strong concavity forwards. The relation between the intergulars and the gulars is difficult to discover. The suture between them at the free margin is distinct, but after proceeding inwards a short distance it appears to divide and take two directions. One depressed line extends backwards to the humero-gular suture, cutting off triangular gulars and extending the intergulars back to the humerals as in *Adocus*. The other depression extends directly across the anterior lobe, cutting off small intergulars as in *Baëna*. In either case the arrangement represents a genus distinct from either of those named. If the intergulars extend to the humerals they are double, the mesosternal region being divided by a distinct longitudinal dermal suture. If the intergulars are short, with the gulars in contact behind them, the arrangement is equally distinct from *Adocus*. From *Baëna* the absence of intersternal bones, and the Emydoid mesosternum distinguish it. It approaches also *Polythorax*,* and may indeed belong to that genus. But it does not appear that the humerals and interhumerals are distinct in the Georgia turtle, and no intermarginals are observed in *Polythorax*. It is therefore necessary to give the present genus a name to be used until its relations to the latter are positively ascertained. I propose AMPHIEMYS for the genus, and A. OXYSTERNUM as the specific name.

Specific characters. The plastron is nearly plane in the transverse direction; longitudinally the posterior lobe is a little raised above the plane, and the anterior lobe rather more so.

The general form is elevated, the vertical diameter being large when compared with the longitudinal and transverse, which preserve usual proportions. The border of the carapace is not flared at the sides, and rises anteriorly to the nuchal bone. The free anterior margin is somewhat undulate. The anterior half of the carapace does not display any median or lateral keels.

The nuchal bone is considerably wider than long, and the costal and

* Cope, Proceed. Acad. Philada. 1876. Nov.

marginal sutures are of about equal length. The vertebrals are all longer than wide, and of the usual form, with truncate antero-lateral angles, excepting the first. This one has both the sides and extremities convex, the latter being of subequal width. The costals are thick, and have parallel borders. The marginals are all higher than long, especially those of the bridge.

The sutures of the plastron are fine and straight. The portion of the mesosternum enclosed by the episternal or clavicular bones has greater longitudinal extent than the part embraced by the hyosternals. The sutures with the clavicular bone are nearly straight, and are parallel with the free border. The common suture of the hyosternals is a little longer than that of the hyposternals, and is a little shorter than that of the postabdominals. The anterior suture of the latter has a slight posterior obliquity, and is abruptly turned backwards at the free borders of the lobe.

The dermal sutures of the carapace are mostly obliterated. Enough remains to show that the second vertebral was wider than long, while the nuchal shield is considerably narrower than the nuchal bone. The marginal scuta are much narrower than the marginal bones, and become narrower forwards. The region of the nuchal marginal is obscure.

Measurements.	M.
Length of carapace to the posterior border of seventh costal	.250
Depth at third vertebral bone	.150
Length of second vertebral bone	.031
Width " " " "	.032
Thickness " " "	.013
Length of first marginal "	.035
Width " " "	.033
Length of first do. of the bridge	.028
Width " " " "	.060
Width of second costal	.033
Thickness of " "	.012
Greatest width of carapace	.182
Length of plastron (axial)	.211
" " anterior lobe (axial)	.073
" " posterior lobe "	.070
Width of base of anterior lobe	.115
" " " posterior "	.086
Length of bridge	.090
" " mesosternum	.042
Width " "	.046
Length of clavicle	.051
" " common suture of clavicles	.014
" " " " " hyosternals	.051
" " " " " hyposternals	.047
Width of postabdominals at anterior border	.057

The shell of this species is thicker than in any species of tortoise now living in North America, a peculiarity characteristic of most of the species of the Cretaceous period, and of many of those of the Eocene. Its size is about that of the *Pseudemys serrata*.

Tenth Contribution to the Herpetology of Tropical America.

By E. D. Cope.

(*Read before the American Philosophical Society, July* 20, 1877.)

The greater number of the species described in this paper were sent to the Smithsonian Institution by its correspondents, and submitted to my examination by its Secretary, Professor Henry.

Bufo melanochlorus Cope

B. valliceps var. Cope, Journ. Academy, Phila., 1865, p. 100.

Orbital borders elevated, and with parietal branch crests, which are prolonged; toes long, nearly free; end of carpus reaching end of muzzle; paratoids large; a lateral dormal fold; tympanum large; green with deep black spots; throat and thorax black.

This toad differs very much in appearance from the *Bufo valliceps*, but is nearly allied in essentials, its other affinities are to the *B. auritus*. The fingers are quite long, but the posterior legs are short, the heel reaching the posterior border of the orbit. The parietal crest is long; the supratympanic is well developed, and preorbital very weak. The front is not narrower, nor does the muzzle project beyond the mouth. The diameter of the very distinct round tympanic disc is half that of the orbit, which is large. The tongue is long and narrow, and the ostia are only half as large as the rather large choanæ. The parotoids are quite small, sub-triangular and directed outwards and backwards. The skin is nearly smooth above, except on the scapular and iliac regions, and is minutely roughened below. There are two tarsal tubercles, and no tarsal fold. Length of head and body, .047; of head, .015; of hind leg, .070; of hind foot, .030.

The allied *Bufo coniferus* Cope differs from this species in its broadly palmate feet, etc.

East Costa Rica, W. M. Gabb.

Bufo canaliferus Cope.

Orbital border reverted crest-like; a preorbital crest; tympanum distinct; head narrow, muzzle projecting; parotoids large, triangular, with scapular angle; rough; brown with dorsal and lateral light bands.

This handsome species is characterized by the narrow gutter-like front, and prominent muzzle, together with the very large, angulate parotoids. The orbital borders are strongly everted, but without parietal branches. The preorbital crest is not very strong, and the supratympanic is quite short. The muzzle is contracted, and overhangs the mouth. The diameter of the distinct *membranum tympani*, is half that of the orbit. The parotoid reaches to above the middle of the humerus, has a straight external, and convex internal outline, and is rather lateral in position. Its lateral truncation is similar to that seen in *B. hæmatiticus*. The skin is tubercular everywhere, finely so below. The posterior limbs are of median length,

the heel reaching to the tympanum. Two rather small tarsal tubercles, no tarsal fold. Soles rough, the palmation measuring the middles of the shorter toes. The tongue is small and narrow; the ostia are a little smaller than the choanæ.

Length of head and body, .054; of head, to posterior line of tympana, 013; width of head at do. .018; length of hind leg, .071; of hind foot, .033.

The color is a light or dark deer brown, with a light vertebral band (rarely absent). On each side of the latter are large brown spots with narrow pale borders. A dark band extends from the orbit to the middle of the side, and above it a broad pale band extends to the groin; inferior surfaces, uniform light yellow.

This species differs from the *B. argillaceus* in its strong cranial crests, projecting muzzle, and large paratoid glands; in the last two characters, and in the narrow front, from the *B. sternosignatus*.

West Tehuantepec, Sumichrast.

Hyla spilomma Cope.

Fingers free; vomerine teeth in transverse series behind line of posterior nares; skin thickened above; tympanum two-fifths eye; frontal bones osseous in front; eye spotted with yellow.

This species is remarkable for the ossification of the anterior portion of the fronto-parietal bones, which are in contact on the middle line near to the ethmoid bone. Posteriorly they are separated, leaving a fontanelle, which represents the posterior portion of the usual one. The species in this respect approximates the genus *Scytopis*.

The head is broad, and the muzzle very short; the canthus are obsolete, and the nostrils a little nearer the end of the muzzle than the orbit. The tongue is wide and entire, and the choanæ small. The palettes are nearly as large as the tympanic disc, and, the toes are quite short, and only about half webbed. The heel of the extended limb only reaches the posterior portion of the orbit.

The superior and lateral integument is thickened and studded on the back with rather large, obtuse, warts. The length of head and body is, .038; of head including tympana, .011; width of head at do., .014; length of hind leg, .052; of hind foot, .023.

The color in these specimens is a light purplish brown, without variations, excepting in one instance. In this one the darker dorsal region is separated from the sides by a broad blackish band which extends from above the tympanum to the groin on each side. The iris is colored in a manner which I do not find in any other species. The pupil appears cruciform, and the interspaces are golden, with a black spot in the outer margin.

This species belongs to the series without webs between the fingers. Among these it is distinguished by the posterior position of the vomerine teeth, moderate tympanum, etc.

From Cosamaloapam Vera Cruz, from Francis Sumichrast.

HYLA BISTINCTA Cope.

Fingers free; vomerine teeth between nares; foot shorter than tibia and femur; tympanum one-fifth diameter of eye; vomerine teeth in small fasciculi; frontal bones ossified in front; blue, sides pale varied; lip not white-bordered.

Size of *Hyla carolinensis*. The head, particularly the interorbital region, is broad and flat; the canthus is distinct; the *membranum tympani* is exceedingly small, and is overhung by a thick dermal fold. The skin of the superior surfaces is smooth. The fore-limbs are very stout, and the animal being a male in breeding condition, the thumb bears two corneous plates on the inner side. The larger of these is the inferior, and forms a strong prominence on the metacarpal. The surface is composed of densely packed points. The posterior limbs are long, the heel reaching nearly to the end of the muzzle. The feet are of moderate proportions, and not fully webbed; the membrane reaches the base of the penultimate phalange of the third and fourth digits, and farther on the fifth.

Length of head and body, .045; of head, .012, width of head at tympana, .015; length of hind leg, .067; of hind foot, .031.

Color, upper surfaces including femur and humerus, dark-bluish plumbeous, without marks; inferior surfaces yellow. Sides marbled with the two colors; posterior face of femur pale brown, with a few yellow specks along the superior border. Eye unspotted.

Vera Cruz most probably; obtained by Dr. Sumichrast with the *H. spilomma* and *H. miotympanum* Cope (= *H. microtis* Peters).

CHOROPHILUS VERRUCOSUS Cope.

The length of the head to the posterior margin of the membranum tympani enters the total length to the vent three and one-sixth times. The head itself is narrow and acuminate, the muzzle projecting acutely beyond the labial margin. The external nares mark two-fifths the distance from the end of the muzzle to the orbital border. The membranum tympani is only one-fourth the diameter of the orbit. The canthus rostralis is distinct, but obtusely rounded. The vomerine fasciculi are approximated, and near the line of the posterior border of the nares, which are larger than the minute *ostia pharyngea*. The tongue is large and wide behind and faintly emarginate.

The heel of the extended hind leg extends to between the orbit and nostril: the femur is short, while the tarsus is long, a little exceeding half the length of the tibia, and exceeding the length of the remainder of the foot, minus the longest toe. The skin of the gular and sternal region is smooth; of the abdomen, areolate. That of the dorsal region is tubercular, smooth warts of large and small size being irregularly crowded over its entire surface, and not at all resembling the areolate surface of the belly.

Color above leaden, with three longitudinal rows of darker, light edged spots, extending, one on each side, and one on the median line. They are each composed of a series of spots joined end to end. Femur and tibia

cross-barred. Upper lip dark plumbeous, with a series of five white spots; a similar spot below the tympanum. Inferior surfaces yellowish.

Length of head and body	.019
" " head	.006
" " hind limb	.026
" " femur	.007
" " tibia	.008
" " tarsus	.005
Width of head at tympana	.0055

From Volusia, Florida; Mrs. A. D. Lungren.

This *Chorophilus* is similar in proportions to the *C. triseriatus*, but is well distinguished by the characters of the skin, and the coloration. The tubercular upper surface is quite peculiar, and the smooth gular region is equally wanting to the Northern frog. The dorsal skin is somewhat like that of *Acris gryllus*.

Lithodytes lanciformis Cope.

Vomerine teeth in two fasciculi which are truncate posteriorly, and are situated behind the posterior line of the posterior nares. The supraorbital borders not thrown into ridges. Tympanum not narrowed. Heel reaching to extremity of muzzle, when the posterior leg is extended. The head is nearly twice as long as the pelvis.

The head and muzzle are flat, the latter narrowed and convex at the extremity. The canthus rostralis is well defined, and the nostril is nearly terminal. The bones are nearly plane and vertical, and their length to the end of the muzzle is twice the diameter of the eye. The latter is one-third greater than that of the tympanum. The choanæ exceed the ostia in size. There are no dermal folds on the back or inferior surface. The metatarsi are all somewhat separated, and connected by a thin membrane, but this is merely due to the attenuation of the usual solar integument. The hind legs are very long; the pallettes small on the hands, and of median size on the feet.

The color above is dark ashen penetrated with pink; there is a narrow median dorsal white line. A broad black band extends from the end of the muzzle across the tympanum, where it contracts to a narrow black line which extends from the superior border of the tympanum to near the middle of the side. The concealed surfaces of the limbs are uniformly dusky; the femur and tibia are pink with dusky cross-bands. There is a dark interorbital cross-band in front of which the muzzle is very pale. Upper lip without dark spots; below immaculate.

Total length M. .026; of head, .011, or 2.4 of the total. Hind limb, .050.

From the "West Coast of Central America," without more specific locality.

This species is easily distinguished by the great relative length of the head, especially as compared with that of the pelvis.

LITHODYTES PELVICULUS Cope.

Lateral borders of the fronto-parietal bones elevated into longitudinal crests, which on the vertex are abruptly incurved without meeting. Tympanic disc a broad vertical oval, as large as eye; vomerine teeth in short, approximated, transverse, fasciculi, behind the line of the posterior border of nares. Head short, very wide, muzzle not projecting. Heel of extended hind foot reaching to middle of orbit. Gray varied with blackish above and below.

This species resembles nearly the *L. megacephalus* Cope, Journ. Acad. Phila., 1875, p. 100, but differs in a number of points. The first is the much greater size of tympanic disc, whose diameter is only about half that of the orbit in the latter; in the posterior incurvature of the superciliary crests (they are straight in *L. megacephalus*); in the much smaller size, the linear dimensions being less than half those of the *L. megacephalus*.

There are two suprascapular longitudinal dermal folds which converge towards the middle line without meeting. Pallettes and tubercles small. Canthus rostralis straight, intercanthal region plane; muzzle a little retreating, nostrils terminal. General color ashen gray; a large black spot below eye, and another above, and on tympanum; muzzle, interorbital, and interscapular regions dusky. Soles and posterior faces of femora black. Concealed faces of hind feet and limbs and abdomen, yellow coarsely reticulated with blackish; throat thickly dusted with the same. A dark band with a pale superior border above each ilium.

The *L. pelviculus* is said to have been found on the west coast of Central America, without more special designation of locality.

PHYLLOBATES CYSTIGNATHOIDES Cope.

This rather small species has the form of the species of *Lithodytes*, as *L. rhodopis* or some of the *Cystignathi*. The muzzle is rather elongate and the front rather convex. The limbs are rather long, and the tubercles on the inferior side of the digits are prominent. The terminal dilations of the toes are of moderate size, and equal on the two limbs.

The apex of the muzzle is narrowed, but rounded, and does not project much beyond the lip. Its distance from the nostril is one-third that between the latter and the orbit. The tympanic disc is very distinct, is subround, and its diameter is one-half that of the orbit. The tongue is pyriform and much narrowed in front. The nares are sublateral, and the *ostia pharyngea* very small. The end of the tarsus extends beyond the muzzle, and the heel marks the middle of the eye. Both tarsal tubercles are distinct. There are strong tubercles along the inferior face of each metatarsal. The skin is everywhere entirely smooth.

Measurements.	M.
Length of head and body	.0225
" " " including tympana	.0075
Width " " at tympana	.0070

	M.
Length of fore limb	.0140
" " " foot	.0050
" " hind limb	.0330
" " " foot	.0155
" " tarsus	.0055
" " tibia	.0100

The color of the upper surfaces is a reddish brown; below, leather brown. The back is thickly spotted with large darker or blackish spots, the largest of which reaches to between the eyes. The sides are marbled with lighter and darker, but the femora are unicolor. Limbs obscurely cross-banded; below uniform, upper lip with a few pale spots.

Numerous specimens of this species were found by Francis Sumichrast at Potrero near Cordova, Vera Cruz, under decayed trunks of trees. It is of more lanciform proportions than the Central American species, *P. hylæformis* and *P. ringens*.

CYSTIGNATHUS LABIALIS Cope.

Vomerine teeth in transverse series behind the posterior border of the internal nares; toes without dermal border; no abdomdinal discoidal fold; posterior limbs short; end of metatarsus just reaching muzzle, muzzle short; not projecting; teeth much behind choanæ; one dermal fold on each side; skin rough; below white.

This small species belongs to that division of the genus, in which the toes do not possess dermal margin, and there is no discoidal fold of the abdominal integument. Among these it is distinguished by the shortness of the series of vomerine teeth and the paucity of dermal plicæ. The muzzle is acuminate and rather narrow, but not projecting as in *C. gracilis;* the canthus is not distinct. The tongue is oval and a little notched behind; the choanæ are small. The diameter of the tympanic disc is one-half that of the orbit. The heel only reaches the orbit. The toes are not very long; there are two small tarsal tubercles, and a narrow tarsal fold.

Color chocolate brown, the limbs darker cross-barred. A brilliant white band extends from the anterior part of the upper lip, and describing a curve upwards, bounds the orbit below and descends to the *canthus oris*, from which point it continues in a straight line to the humerus, and ceases. Inferior surfaces, pure white. Length of head and body, .020; of head, .007; of hind limb, .028; of hind foot, .013.

The precise *habitat* of this species is at present uncertain. It is probably a part of Sumichrast's Mexican collection.

SIPHONOPS PROXIMUS Cope.

Tentacular fossa close to eye; annuli complete; muzzle depressed, elongate, narrow; rings $\frac{0}{27}\ \frac{13}{83} - 19 = 129$ or $\frac{0}{28}\ \frac{74}{74} - 27 = 129$; longer than *S. mexicanus*.

This Caecilian resembles so much the *S. mexicanus* that I referred specimens of it to that species in my Batrachia and Reptilia of Costa Rica. It

possesses the same produced, flattened muzzle, with distinct eye, and the coloration is similar, but the position of the tentacular fossa is quite different, and the general form is more elongate and slender. The diameter is about the same. Length, .425; diameter, .017.

Coast of Eastern Costa Rica; W. M. Gabb.

Siphonops simus Cope.

Tentacular fossa close to eye; annuli complete; muzzle wide, truncate, nostrils terminal; annuli 228; anterior 8 undivided; 22 posterior fully divided by intermediate plicæ.

The form of the head of this species is different from that of any other *Siphonops* of Mexico or Central America, and its annuli are more numerous. They continue to the anus, and those of the principal series are nowhere divided on the middle line. The form is not slender, but is more so than in the *S. mexicanus*, resembling in this respect the *S. proximus*. Length, .308; diameter at middle, .011. Color dark brown; below a little paler.

This species was found in Costa Rica, the exact locality being uncertain. From Dr. von Franzius.

Siphonops oligozonus Cope.

Tentacular fossa close to eye; many annuli incomplete; muzzle narrow, projecting; eye invisible; nostrils lateral; annuli of principal series 119, of which 14 anterior and 42 posterior are complete; of second series (none in anterior 72 annuli), 34 incomplete and 13 complete.

This Batrachian resembles at first sight the *Cæcilia ochrocephala*, as it possesses the same yellowish head and brown plumbeous body. It is abundantly distinct from the other species of the genus in various respects, combining the interrupted annuli of some of the Brazilian species, with a narrower, projecting muzzle, and invisible eye. The annuli continue to the vent, and those of the secondary series commence much posterior to the point of beginning in the other species. Length, 0.263; diameter, .005.

The precise *habitat* of this species is uncertain.

Cæcilia isthmica Cope.

General form robust. Muzzle flat, rather wide, and projecting far beyond the mouth. Tentacular fossa near the edge of the lip a little behind and below the line of the nostril. Eye distinct. Annuli one hundred and forty-two, of which only the last sixteen surround the body, the anterior one hundred and twenty-six being interrupted both on the dorsal and abdominal lines. Between the last seven rings are additional plicæ, which cross the dorsal line and extend on the side, but are not continued across the abdominal line. Length, .570 mm.; diameter (which is about uniform), .020; length to rictus oris, .017. The general color in alcohol is dark brown; the inferior surface is a little paler.

This species was included in the collection made by Commander Selfridge

on the East side of the Isthmus of Darien. The species obtained are the following:

Dipsas cenchoa L.
Oxyrrhopus clelia L.
Leptophis occidentalis Gthr.
Herpetodryas carinatus L.
Rhadinæa ignita Cope.
Pliocercus euryzonus Cope.
Ophibolus micropholis Cope.
Nothopsis rugosus Cope.
Ninia atrata Hallow.
Diploglossus monotropis Kuhl.
Anolis laticeps Berth.
Caecilia isthmica Cope.

HELICOPS TRIVITTATUS Cope.

Scales in seventeen longitudinal rows, all keeled excepting the inferior two. The keels are moderately and equally developed throughout the entire length. The last maxillary tooth is not much longer than the others, and it is separated from the penultimate by a space which a little exceeds those between the anterior teeth. The internasal plate is nearly triangular, the rostral is wider than high, and the nasal is as long as wide, and is divided downwards from the uplooking nostril. Loreal twice as high as long; oculars 1–2, the anterior narrow, and well separated from the frontal. Two long large temporals on the external side of each parietal, the anterior occupying the space behind the postoculars. Superior labials eight, the eye resting on the fourth only; the fifth and sixth subequal, the seventh a little larger. Gastrosteges 121; urosteges 78; anal divided.

Color above dark brown, with an indistinct pale vitta on the fifth row of scales, and a yellow vitta on the adjacent halves of the first and second rows. Belly yellow with three longitudinal dark brown bands; the median only preserved on the tail.

Total length, .540; length of head to rictus, .015; of tail, .180.

Habitat unknown, but supposed to be the Argentine Confederation.

OXYRRHOPUS RUSTICUS Cope.

Head but little distinct from the body, front convex, muzzle slightly protuberant. Grooved tooth not much longer than those preceding it. Rostral plate as high as wide, convex and produced backwards above; internasals and prefrontals broader than long. Frontal with longer anterior than lateral borders, superciliaries narrow, parietals short. Nasals large, loreal longer than high, produced backwards to the orbit below the very small preocular, which is widely separated from the frontal. Postoculars two, in contact with one temporal. Temporals 2–3. Superior labials seven, eye resting on third and fourth; fifth higher than long. Eye rather small. Inferior labials nine, the fifth the longest, and in contact with the postgenecial. Geneials equal. Scales equal, rather wide, with double fossæ, and in nineteen rows. Tail short. Gastrosteges 223; urosteges 54; anal entire.

Dark yellowish brown above, the scales indistinctly blackish bordered; below uniform yellow; upper lip yellow.

This *Oxyrrhopus* is distinguished by a robust and obtuse form in a higher

degree than its nearest ally the *O. plumbeus*. The form of the rostral plate, peculiar relations of the loreal and preoculars, with the single temporal in contact with the postoculars, short tail, and color serve to distinguish it from that species.

From the same locality as the last. With them were collected the following species.

Hyla vauterii Bibr.
Aporophis anomalus Gthr. (*L. rutilus* Cope).
Dryophylax schottii Fitz.
Dryophylax olfersii Licht.
Opheomorphus merremii Neuw.
Thamnodynastes nattereri Mik.
Herpetodryas carinatus L.

CNEMIDOPHORUS MICROLEPIDOPUS Cope.

A species distinguished by the small size of the scales on the brachium and thigh.

A few rows of large scales on the collar; the edge with much smaller scales; two preoculars and a frenoöcular; three supraorbitals; larger gular scales few and in the centre of the throat; postbrachials numerous, small; brachials in 3, femorals in 14 rows; olive, with eight indistinct pale bands, black between the two inferior.

There are several flat small scuta behind the parietals and interparietals.

There are a few points of coloration to be observed in describing this lizard. There are four yellow spots at the corners of an imaginary square which encloses the tympanic disc. There is another between the anterosuperior of these and the orbit, and another below the posterior part of the eye. The inferior yellow line is continued on the tail.

About the size of *C. sexlineatus;* as the median dorsal lines are faint in the single specimen is not probably young.

West Tehuantepec, Sumichrast.

CNEMIDOPHORUS UNICOLOR Cope.

A small species distinguished by the absence of coloration marks.

A few rows of large scales on the collar; the edge with much smaller scales; two preoculars and a frenoöcular; three supraorbitals; larger gular scales few and in the centre of the throat; postbrachials larger, above point joining brachials which are in 5 rows; femorals in 10; olive brown with one pale lateral line; four pale spots below and behind eye.

There are four yellow spots round the tympanic membrane, one below the eye, and one between the latter and the nearest one of the former, as in *C. microlepidopus*. The dorsal scales are minutely roughened. It is in general characters allied to the *C. inornatus* Baird from Northern Mexico. The latter differs in the presence of four supraorbital plates, smaller collar scales, and coarser and rougher dorsal scales.

West Tehuantepec, Sumichrast.

CNEMIDOPHORUS IMMUTABILIS Cope.

This species attains to the largest size known in the genus, without losing its striped coloration, as do the other large forms.

Several rows of large scales on the collar, the border row not larger nor much smaller; two preoculars and a frenoöcular; larger gulars median, three supraorbitals; postbrachials small; brachials in 3, femorals in ten rows; adult with eight longitudinal bands; femora pale spotted.

The small size of the postbrachial and femoral scales, relate this species to the *C. guttatus*, but it lacks the small scales of the border of the fold seen in that lizard. The interparietal in an adult is narrow. The temporal region is covered with minute scales. There are numerous small scuta behind the parietals. There are two rows of antebrachial scuta well defined at the borders. Two rows between the inferior and infralabials. The inferior lateral brown band extends to the orbit. Throat pale; breast plumbeous.

West Tehuantepec, Sumichrast.

Cnemidophorus lineattissimus Cope

This swift lizard is of medium size in the genus, and maintains the lined coloration intact.

Several rows of large scales on the collar, the border row not larger nor much smaller; two preoculars; no frenoöcular; three supraorbitals; larger gulars extending across throat; superior preocular not descending to labials; postbrachials large, continuous with brachials; femorals in eight rows; black, with ten or eleven pale bands; sides and femora pale spotted; throat black.

The muzzle is rather acute but not elongate, and the fronto-nasals have considerable mutual contact. The larger and smaller gulars are abruptly distinguished from each other, and the former are smaller than the scales of the collar. The frenal plates form a circle surrounding a large median scute, of which the two posterior plates are the largest.

There is a space between the two submedian lines, which is often divided by a median line. Below the lowest line the sides are black with large light spots, open below.

Colima, Xantus; Guadalaxara, Major.

Cnemidophorus lativittis Cope.

Several rows of large scales on the collar, the border row not larger nor much smaller; two preoculars, the superior not descending; no frenoörbital; supraorbitals 3; larger gulars extending across the throat; post brachials large, continuous; femorals 8 rows; olive, with eight wide bands, ground black between second and third

The nostril is in front of the nasofrenal suture. Parietals and interparietals of normal proportions, surrounded by a series of moderate scales, in a semicircle. One row between the inferior labials and infralabials. Brachials large, in five continuous rows, distinct, no postbrachials. Two rows of antebrachials. Scales of collar equal those of gular region, larger than postgulars, and smaller than abdominals. Femoral pores seventeen.

Color below bluish; pectoral region blackish; there are small yellow

spots on the external abdominal scuta and on the femora. A longitudinal yellow line on the posterior face of the femora.

Total length, M. 0.255; length to tympanic drum posteriorly, .020; to vent, .076; length of hind limb, .051; of hind foot, .026.

Tuchitan, Tehuantepec, Sumichrast.

This handsome species is, in the number of its longitudinal stripes, similar to the *C. octolineatus* of Baird. That lizard differs in having four supraorbital plates, and smaller collar scales; the stripes are also much narrower.

Cnemidophorus communis Cope.

This species is near to the *C. sexlineatus* in its characters, but constantly differs in the presence of the frenoörbital plate. It is also much larger, the males equaling the large Amivas.

A few rows of large scales on the collar, of which the marginal is the largest; two preoculars and a frenoöcular; four supraorbitals; large gulars extending across throat; postbrachials and brachials large, continuous; three large preanals; femorals in 8-9 rows; olive, with six light bands with light spots in the intervals, the former breaking into spots in the adult male.

There are two varieties of this lizard. In the first, there are rows of light spots in the spaces between the stripes in the females; while in the males the stripes are broken up into round spots so as to give a coloration like that of the *C. guttatus*. In the second variety there are no spots and the bands are unbroken. The specimens resemble the young of var. 1.

Var. I. Colima, Xantus; Coban, Guatemala, Hague.

Var. II. Guadalaxara, Major; Cordova, Sumichrast; Guatemala, Hague; San Antonio, Texas.

Cnemidophorus angusticeps Cope.

This species is in general characters similar to the last, but it differs in the coloration, and in the very narrow form of the parietal and interparietal plates.

A few rows of large scales on the collar, of which the marginal is the largest; two preoculars and a frenoöcular; four supraorbitals; similar but interparietal and parietal scuta half as wide; ground color black and bands much wider and not broken up in male.

The color stripes of this species if assumed to be those of the paler color, are much wider than the ground, and instead of becoming broken up as in *C. communis*, send off lateral processes, which give the dark ground color a very broken character. The color of the bands is an olive green. The adult male is of about the size of those of *C. communis* and *C. guttatus*.

Yucatan, Schott.

Cnemidophorus costatus Cope.

In general characters this lizard resembles the last two, but it differs in the shorter head, and strikingly in the coloration.

A few rows of large scales on the collar, of which the marginal is the largest; two preoculars and a frenoöcular; four supraorbitals; similar to *C. communis*, but head shorter and scuta wider; brown with black cross-bands on sides, which join across the middle line on the lumbar region; sacral region and femora white spotted.

The short head of this species is accompanied by an abbreviation of the sutures of mutual contact of the fronto nasal and internasal pairs of scuta, which is not seen in the other allied species. The unique specimen is smaller than the females of the two species last described, yet it presents no trace of stripes. From its coloration I should suppose it to be an adult male.

The locality of this specimen is only stated to be "Mexico."

GERRHONOTIDÆ.

The important variations in the scutellation of the head of the species of this family lead to the view that several genera are indicated. The definitions of these are as clear as those of many genera of the system, and as it appears to me, may be profitably associated with names as elsewhere. There is a tendency to subdivision of the head-shields in some species, it is true, but a little patience in studying the homologies of the portions separated in excess, will refer them to their proper positions and reduce them to the types herein mentioned. Dr. Gray, in 1845, attempted to distinguish four genera among the species of the original genus *Gerrhonotus* of Wiegmann, but the characters he seized upon do not, with one exception, possess the importance he attached to them. The exception is that of *Barissia*, which has maintained its distinctive feature, the absence of the interfrontonasal scutum. Two species recently described by Bocourt exhibit, according to that herpetologist, the equally important feature of the absence of the frontonasal plates. The great subdivision of the plates of the internasal region distinguishes a number of species, one of which was named long since *Pterogasterus* by Messrs. Peale and Green.

PTEROGASTERUS Peale and Green.

Three pairs of internasal scuta; interfrontonasals and frontonasals present.

Species: *P. ventralis* P. & G.; *P. tessellatus* Wiegm.; *P. ophiurus* Cope; *P. infernalis* B. & G.; *P. lemniscatus* Boc.; *P. modestus* Cope, sp. nov.

GERRHONOTUS Wiegmann.

Two pairs of internasals; interfrontonasals and frontonasals present.

Species: *G. multicarinatus* Blv.; *G. grandis* B. & G.; *G. scincicaudus* Skilt.; *G. principis* B. & G.; *G. kingii* Gray; *G. gramineus* Cope; *G. auritus* Cope; *G. tæniatus* Wiegm.; *G. deppei* Wiegm.; *G. formosus* Bd.; *G. vasconcelosii* Boc.; *G. rhombifer* Pet.; *G. monticolus* Cope, sp. nov.

MESASPIS Cope, gen. nov.

Two pairs of internasals; interfrontonasal present; frontonasals wanting.

Species: *M. moreletii* Boc.; *M. fulvus* Boc.

BARISSIA Gray.

Two pairs of internasals; interfrontonasals wanting; frontonasals present.

Species: *B. antauges* Cope; *B. bocourtii* Pet.; *B. lichenigera* Wiegm.; *B. imbricata* Wiegm.; *B. rudicollis* Wiegm.

An extinct genus of the family has been found in the Miocene beds of the White River group of Colorado, which I have called *Peltosaurus.** The scales in that genus were conjoined by sutural borders and not imbricate, as in the recent genera.

PTEROGASTERUS MODESTUS, sp. nov.

Scales $\frac{4}{12}$ slightly convex above, but not keeled, excepting those of the tail, which are strongly and obtusely carinate or ribbed; an azygos scute between the two anterior pairs of internasals. Internasals of first pair reaching first labials. Internasals of third pair elongate, in contact with frontonasals behind, apparently including the small lateral interfrontonasals. Two postnasals; a large plate, the anterior canthal, descends to the labials, from the inferior part of which a loreal may be separated. Preoculars two or one. Two pairs of large infralabials in contact, following the symphyseal, without a postmental; two pairs follow, of which the anterior are separated by one scute. Lateral fold extending from ear to vent; the granular area extending above the humerus. Appressed limbs separated by six cross-rows of abdominal scales, or the length of the fore arm. Rows of scales from nape to origin of tail, forty-seven; do. from front of humerus to vent, thirty-eight.

The tail is not very long and is grooved below as well as above. Total length, .150; length to meatus auditorius, .012; to vent, .072; length of hind leg, .019. Color above, brown; below, olivaceous. The sides are a reddish-brown or maroon, bordered above by a blackish line which separates it from the dorsal color.

This species differs from all others of the genus in the extinction of the small plate which truncates the lateral angle of the interfrontonasal. As a consequence of this, the latter has a diamond shape, as it does not reach the frontal plate behind nor the azygos plate in front. The smooth scales also separate it from all others of the genus.

The precise locality from which the specimens of this lizard were sent to the Smithsonian Institution is uncertain, but is probably Guatemala.

GERRHONOTUS MONTICOLUS, sp. nov.

"*Gerrhonotus fulvus* Boc," Cope, Journ. Ac. Phila., 1865, p. 118, nec Bocourtii.

Scales keeled on the middle line of the back, to the number of three or four rows; other dorsal and lateral series smooth; those of the superior surface of the tail keeled strongly. Lateral fold extending from ear to vent; granular scales extending above the humerus. Scales above and

* Annual Report U. S. Geol. Surv. Terrs., 1873, p. 512.

below $\frac{8}{12}$; forty-five transverse rows between nape and origin of tail, and thirty-six rows between front of humerus and vent.

The interfrontonasal is transversely diamond-shaped, and has no external plates at its lateral margins. The frontonasals have considerable mutual contact. There are two postnasals; the anterior (and only) canthal descends to the labials, taking the place of the loreal, and there is one large preocular. A postmental follows the symphyseal, and then one pair of infralabials in contact. Two pairs follow, the anterior interrupted by one, the second by two, scales. The auricular opening is nearly as long as the fissure of the eye. The appressed limbs are separated by the space of four ventral cross-rows, or the length of the longest digit of the manus. The tail is of moderate length.

Color of upper surface and sides, brown, the latter a little darker, and bounded above by a narrow black line. A somewhat irregular row of small black spots down the median dorsal line. Below yellowish olive, the scales of the abdomen with black borders, those of the gular and thoracic regions with black centres.

Total length, M. .143; length to auricular meatus, .012; to axilla, .023; to vent, .061.

From the summit of the Pico Blanco (elevation 11,500 feet) in the Eastern Cordillera of Costa Rica; W. M. Gabb.

This species I provisionally identified with the *G. fulvus* of Bocourt, which has been found in Guatemala. The two species are probably nearly allied, but present a difference in the cephalic scutellation, which is of generic value.

Further Illustrations of Central Force.

By Pliny Earle Chase, LL.D.,

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(*Read before the American Philosophical Society, July 20th*, 1877.)

The establishment of centres of oscillation and harmonic nodes, in an elastic medium, is a necessary consequence of the principle that "a system of bodies in motion must be regarded mechanically as a system of forces or powers which is a perfect representation of all the single powers of which the system is compounded, and this, too, at whatever time or times the component powers may have been introduced into the system." *

But since it is often more difficult to grasp truths which are presented under new aspects, than those which are clothed in familiar garbs, it may be well to glance at some of the most obvious tendencies to nodal action, which result from simple gravitating fall towards a centre. The exami-

* Peirce. Proc. A. A. S., II, 111.

nation will be the more interesting and suggestive, because like tendencies must exist in all central forces which vary inversely as the square of the distance.

Ennis* has called attention to the fact, that the difference between the velocity of infinite radial fall $(\sqrt{2gr})$ and circular-orbital velocity $(\sqrt{gr})$, must be accounted for in some way, and he thinks that it may be sufficient to explain all the phenomena of planetary rotation and revolution.

In nebular condensation from r to $\frac{r}{n}$, the increase of radial velocity is $(\sqrt{n}-1)\sqrt{2gr}$; the circular-orbital velocity at $\frac{r}{n} = \sqrt{ngr}$; therefore the increase of radial velocity would be sufficient to produce orbital velocity in the periphery of a stationary nebula, when $\sqrt{n} = \sqrt{2}\ (\sqrt{n}-1)$, and $n = \frac{2}{3-2\sqrt{2}} = 11.656854$. If r be made to represent, successively, all points between secular aphelion and secular perihelion, in the hypothetical nebulous belts which were condensed into Neptune, Uranus, Saturn and Jupiter, this fall of condensation from Neptune would give orbital velocities in the asteroidal belt; from Uranus, in the Mars belt; from Saturn, in the Venus belt; and from Jupiter, in the Mercury belt. Earth, as I have already shown, is at the centre of the primitive inter-asteroidal belt, which appears to have been then broken up by the action of Uranus, Saturn and Jupiter.

Neptune,	$\div n =$	2.577	Astræa,	=	2.577
Uranus, s. p.,†	$\div n =$	1.517	Mars,	=	1.524
Saturn, s. p.,	$\div n =$	.749	Venus, a.,	=	.749
Jupiter, s. a.,	$\div n =$	.473	Mercury, s. a.,	=	.477

This would leave the orbital velocities of the four outer planets to be accounted for by like condensation from an earlier nebulous condition, of which we have no visible evidence, but if the main hypothesis is correct, we may reasonably look for confirmation of a different kind, within the present limits of the solar system. If we consider the *vis viva* of orbital and radial velocity for unit of mass, the *v. v.* added by radial fall from r to $\frac{r}{m}$ is $(m-1)\,gr$, while the *v. v.* added by equivalent orbital contraction is only $\frac{1}{2}(m-1)\,gr$, or one-half of the radial addition. A simple nebular condensation from r to $\frac{r}{2}$ would, therefore, add gr to the *v. v.*, which is equivalent to the *v. v.* of circular-orbital revolution at $\frac{r}{2}$. There is, therefore, a tendency to repeated nebular ruptures at $\frac{r}{2}, \frac{r}{4}, \frac{r}{8} \cdots \frac{r}{2^m}$.

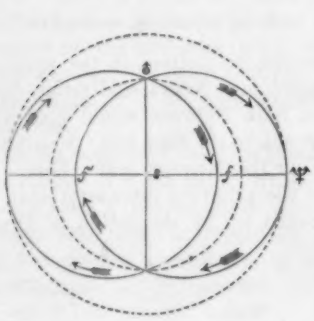
Starting from the present outer limit of our system, Neptune's secular

*"Origin of the Stars."

†a., *aphelion*; p., *perihelion*; s., *secular*.

aphelion (30.46955), these rupturing nodes would occur at 15.23478; 7.61739; 3.80870; 1.90435; .95217; .47608; .23804. The first belt would include Neptune and Uranus; the second, Saturn; the third, Jupiter; the fourth, the asteroids; the fifth, Mars and Earth; the sixth, Venus (grazing also the Earth and Mercury belts); the seventh, Mercury.

After the nebula had assumed a globular form, these rupturing nodes would occasion constant tendencies from opposite extremities of every diameter, to the formation of confocal elliptic orbits, with major axes of $\frac{3r}{2}$ and minor axes of $\sqrt{8r}$. Those ellipses would mutually intersect at $\frac{2r}{3}$, thus tending, through collision of particles, to form a belt at that distance from the centre. The *v. v.* communicated by simple fall from r to $\frac{2r}{3} = \frac{1}{12}gr$, which is equivalent to *v. v.* of circular-orbital revolution at r, and also to the orbital *v. v.* gained by contraction from r to $\frac{r}{2}$.



The internal motions and collisions of the particles of the belt would form a condensation of the densest and comparatively inelastic materials, until the whole acquired the mean orbital *v. v.*, $\frac{gr + 2gr}{4} = \frac{3gr}{4}$, which is the normal orbital *v. v.* at the nodes of aggregating collision, $\frac{2r}{3}$. The following table exhibits the double tendency, to nebular rupture and to nebular aggregation, starting from the point which would account for the orbital velocity of Neptune. The approximation of "B" to the planetary distance which would satisfy Bode's law, and the indications of Neptunian aggregation during direct fall towards the centre, lend new confirmation to the views which I have already expressed, in regard to the *rationale* of Bode's law, and the relative masses of the two outer planets.

		Rupturing Nodes.	Secondary Nodes.	Planets.		
$2 \times$	♆ a*	60.93910	40.62606	"B"	=	38.8
	♆ a	30.46955	20.31303	♁ a	=	20.68
$\frac{1}{2}$	♆ a	15.23478	10.15652	♄ a	=	10.34
$\frac{1}{4}$	♆ a	7.61739	5.07826	♃ p*	=	4.89

* a secular aphelion; p secular perihelion.

The following tables exhibit the modifying influences of other simple nodes :

$\frac{3}{5}$ ♂	1.0158	⊕	1.0000	$\frac{1}{2}$ ♂	.7618	♀ *a*	.7744
$\frac{3}{5}$ ⊕	.6667	♀ *p*	.6722	$\frac{3}{5} \times \frac{3}{5}$ ♂	.6772	♀ *p*	.6722
$\frac{3}{5}$ ♀	.4822	☿ *a*	.4768	$\frac{1}{2}$ ⊕ *p*	.4661	☿ *a*	.4768
$\frac{3}{5}$ ☿ *a*	.3178	☿ *p*	.2974	$\frac{1}{3}$ ⊕ *p*	.3111	☿ *p*	.2974

In the inter-asteroidal belt and ellipse, bounded by ♂ *a* and ☿ *p:*

Middle of belt,	1.0169	⊕	1.0000
Middle of ellipse,	.7194	♀	.7233

Jupiter is similarly situated in reference to the Neptune-Uranian, and the Uranus-Saturnian ellipses :

Middle of ♆ *a* ♁ *a*	4.8952	Middle of ♁	♄ 4.8224	⚳ *p*	4.8863
" ♆ *p* ♁	5.2073	" ♁	♄ *p* 5.2246	⚳	5.2028
" ♆ *a* ♁	5.6430	" ♁ *a*	♄ 5.5701	⚳ *a*	5.5193

Saturn is similarly situated in reference to the Neptune-Saturnian and Sun-Uranian ellipses :

Mid. ⊙ ♁ *p*	8.8440			♄ *p*	8.7345
" ⊙ ♁	9.5918	Mid. ♄ *a* ♆ *p*	9.6275	♄	9.5389
" ⊙ ♁ *a*	10.3396	" ♄ *p* ♆ *p*	10.4319	♄ *a*	10.3433

There are, doubtless, many other results of early inter-orbital action, especially in connection with collisions in confocal ellipses, which would furnish interesting subjects of investigation. For example, when the Jupiter belt was completely severed (⚳ s. p.), and the Earth and Venus belts were beginning to form (s. a.), the orbital collisions were near the limits of the Mars belt.

Elliptic collision	⚳ s. p.	⊕ s. a.	1.753	♂ s. a.	1.736
" "	⚳ s. p.	♀ s. a.	1.337	♂ s. p.	1.311

If we take the radius of nebular rupturing fall for the surface of Sun's homogeneous luminiferous atmosphere (2 × light-modulus), and reduce it in the ratio of mean radially-varying to uniform-circular velocity $\left[\frac{2}{\pi}\right]$*, rupturing nodes ($\frac{1}{2}$) and falls of condensation (1 ÷ 11.656854) give the following table :

		1st Cond. Fall.	2d Cond. Fall.	Rad. Vec.	
4 M ÷ π	2807.4	240.84	20.67	♁ *a*	20.68
2 " "	1403.7	120.42	10.33	♄ *a*	10.34
1 " "	701.9	60.21	5.17	⚳	5.20
$\frac{1}{2}$ " "	350.9	30.10	....	♆	30.03
$\frac{1}{4}$ " "	175.5	15.05	1.29	♂ *p*	1.31
$\frac{1}{8}$ " "	87.7	7.53	.65	♀ *p*	.67

This seems to point, like the Neptune-Saturnian ellipse in a previous

* If synchronous undulations are interrupted by an obstacle, so as to produce accelerated motion towards a centre, the mean radius of variable motion is $\frac{2}{\pi}$ the radius of corresponding uniform motion.

comparison, and like the present comparatively nebulous condition of Saturn itself, to Saturn as an important centre of early ring aggregation, as if our nebula were, at first, a ring vortex. The indication is confirmed by the similar densities of Saturn and Neptune; the similar densities of Uranus, Jupiter and Sun; the fact that "these four planets form a system by themselves, which is practically independent of the other planets of the system;"* the present approximate accordance between the transit of light through the Uranus-Telluric major-axis and the limit of planetary velocity at Sun's surface; and the following comparison between the 2d and 3d condensation falls:

Rad. Vec.		2d C. Fall.	3d C. Fall.	Rad. Vec.	
☉ *a*	20.68	20.67	1.77	♂ *a*	1.74
♄ *a*	10.34	10.33	.89	⊕ *p*	.93
♃	5.20	5.17	.44	☿ *a*	.48
Ast.	2.59	2.59	.22	♀ *a*	?

If the 3d fall had been counted from Saturn's secular perihelion instead of from his secular aphelion, the distance would have been .75, Venus's mean aphelion being .75.

The peculiar indication of the Uranus-Telluric ellipse, the central position of Earth in the belt of greatest density, and the absence of any explicit indication of our planet in most of the foregoing comparisons, suggest the possibility that its place may have been fixed by a special law. Its secular perihelion (.93226) is near the fifth rupturing node of Neptune's mean distance ($30.03386 \div 2^5 = .93856$).

The stellar-Solar parabola points to a time when *a* Centauri may have been at a nebular rupturing point, relatively to the Sun. The lowest and highest estimates for $\frac{2}{\pi}$ *a* Centauri, are, respectively, 28905200 and 30895100 solar radii. The seventh fall of condensation $(1 \div 11.656854)^7$, would give .9883 and 1.0564, showing a closeness of approximation to the present solar radius which can hardly be thought accidental. As there are two falls of condensation between $\frac{2}{\pi}$ Earth and Sun, there are five falls between *a* Centauri and Earth; the extreme range of estimates for *a* Centauri $\div 11.656854^5$ being between .9818 and 1.0494 times Earth's mean radius vector. Both of these points are within the Earth belt ($p = .9323$, $a = 1.0677$).

Neptune's secular eccentricity seems to have been determined by the combined influence of condensation-fall, orbital collision, and rupturing nodes. For Neptune's secular perihelion $\div 11.656854 = 2.53912$; $\frac{3}{5}$ sec. aph. $\div 2^3 = 2.53913$.

The *gegenschein*, and other indications that the Zodiacal light may be partly owing to the remains of an early terrestrial ring, may naturally lead us to look for evidences of residuary activity in some of the outer

* Stockwell; *Smith. Con.* 232, xiii.

planets. A radial oscillation at Uranus's secular aphelion would be accomplished in $10.3396^{\frac{3}{2}} = 33.247y$; a circular revolution at Saturn's secular aphelion, in $10.3433^{\frac{3}{2}} = 33.265y$; a circular revolution, at Jupiter's *mean* perihelion, in $4.9872^{\frac{3}{2}} = 11.108y$. The November meteoric cycle is $33.25y$; the Wolf Sun-spot cycle, $11.07y$.

There is a noteworthy numerical correspondence between the seven rupturing nodes within the planetary belt, and the seven condensation-falls from a Centauri to $\frac{\pi}{2}$ Sun. The fifth node and the fifth fall both come within the Earth belt.

If we suppose seven successive transformations of uniform into variable velocity, before the determination of the present solar mass and light-modulus (M), and five condensation falls ($n = 1 \div 11.656854$) after each transformation, we have the following approximations:

π^7	M	$\div$	n^5	30.941	♆ a	30.470
π^6	M	$\div$	n^5	9.849	♄	9.548
π^5	M	$\div$	n^5	3.135	Hygeia	3.121
π^4	M*	$\div$	n^5	.998	⊕	1.000
π^3	M	$\div$	n^5	.318	☿ p	.297
π^2	M	$\div$	n^5	.101		
π	M	$\div$	n^5	.032		

The probability of undulating gravitating action is increased by the investigations of Bjerknes, who has shown (Comptes Rendus, lxxxiv, 1377) that two spheres, having concordant pulsations, attract each other inversely as the square of the distance; and that they repel each other according to the same law if their pulsations are opposed.

The use of the parabola† in representing expanding action is recognized by H. Ste.-Claire Deville, who states, in considering cases where vapor-densities vary with the temperature, that "the movement of a material point, taken in the expanding material, may be accurately enough represented by a parabolic function of the second degree already employed by M. Fizeau." (Comptes Rendus, lxxxiv, 1257). Deville hopes to employ the resulting relations usefully in expounding some principles of Thermo-Chemistry.

The hypothesis that the radial *vis viva* of mean rectilineal velocity may be taken as the representation of increments of heat under constant volume, while the radial *vis viva* of synchronous constant velocity, will represent simultaneous increments of heat under constant pressure,‡ assumes that the gaseous condition is perfect.

If the Sun were nebulously diffused to 2 ♆, the equal centrifugal and

* π^4 M = distance of a Centauri.

† *Ante*, xvi, 507.

‡ *Ante*, xiv., 651.

centripetal action and reaction would tend to produce a belt of "constant volume," with an inner limit at 1.4232Ψ from the equatorial surface, or $.5768\Psi$ ($= .2884\ r$) from the nucleal centre. The consequent thermodynamic undulations, the *vis viva* of central fall, the vertical collisions at $\frac{2}{3}\ r$, and Ennis's centripetal momentum, would all be simultaneously operative, and the present evidence of their past activity is unmistakable. For if we designate the primitive radius ($2\ \Psi_5$) by a; the thermodynamic ratio (.2884) by $\frac{1}{m}$; the *vis viva* ratio by $\frac{1}{2}$; the collision ratio by $\frac{2}{3}$; the Ennis, or momentum ratio ($1 \div 11.656854$) by $\frac{1}{n}$; secular perihelion, mean perihelion, mean, mean aphelion and secular aphelion respectively, by subscript $_{1,2,3,4,5}$, we find the following primary accordances:

$a = 2\ \Psi_5$	60.939		
$\frac{2}{3}\ a$	40.626		
$\frac{1}{2}\ a$	30.470	Ψ_5	30.470
$\frac{1}{m}\ a$	17.575	$\circledcirc_1$	17.688
$\frac{1}{n}\ a$	5.228	$\mathcal{U}_3$	5.203

The inner limit of the Neptune-Uranian belt, the controlling centre of planetary mass, and, as we shall presently see, the nebular surfaces which were to determine subsequent planetary aggregations, were thus marked out, within less than one per cent., "in the beginning."

The order of time in which these dissociating influences would be completed, would be $\frac{1}{m}$, $\frac{1}{2}$, $\frac{2}{3}$, $\frac{1}{n}$. Second and third dissociations present the following agreements:

$\frac{2}{3}\ \frac{1}{m}\ a$	11.717		
$\frac{2}{3}\ \frac{1}{2}\ a$	20.313	$\circledcirc_4$	20.044
$\frac{1}{2}\ \frac{1}{m}\ a$	8.788	$\flat_1$	8.734
$\frac{1}{m} \cdot \frac{1}{m}\ a$	5.069	$\mathcal{U}_4$	4.978
$\frac{1}{n} \cdot \frac{1}{2}\ a$	2.614	Ast.	....
$\frac{1}{n} \cdot \frac{2}{3} \cdot \frac{1}{2}\ a$	1.743	σ_5	1.736
$\frac{1}{n} \cdot \frac{1}{m}\ a$	1.508	σ_3	1.524
$\frac{1}{n} \cdot \frac{2}{3}\ \frac{1}{m}\ a$	1.005	$\oplus_3$	1.000
$\frac{1}{n} \cdot \frac{1}{2} \cdot \frac{1}{m}\ a$	.754	φ_4	.749
$\frac{1}{n} \cdot \frac{1}{n}\ a$	.448	$\mathbb{Y}_4$	.455

Second dissociations, therefore, approximately fixed cardinal positions of

♁, ♄, 𝔘, the asteroidal belt, ♂, and ☿ ; third dissociations, of ♂, ⊕ and ♀.

Numerous other interesting relations, of a similar nature, may be traced at successive stages of nebular condensation, of which some examples are given in the following table :

$\frac{1}{m}$	Ψ_4	8.749	$♄_1$	8.734
$\frac{1}{m}$	$♁_3$	5.533	$𝔘_5$	5.519
$\frac{1}{m}$	$♂_4$	.474	$☿_5$	.477
$\frac{1}{m}$	$⊕_4$	.298	$☿_1$	.297
$\frac{1}{m^2}$	$♁_2$	1.524	$♂_3$	1.524
$\frac{1}{m^2}$	$♄_1$	.726	$♀_3$	.723
$\frac{1}{m^2}$	$𝔘_5$	.459	$☿_4$	.455
$\frac{1}{m^3}$	Ψ_3	.720	$♀_3$	.723
$\frac{1}{n}$ .2	Ψ_4	5.205	$𝔘_3$	5.203
$\frac{1}{n}$	$♁_3$	1.646	$♂_4$	1.644
$\frac{1}{n}$	$♄_1$	.749	$♀_4$	.749
$\frac{1}{n}$	$𝔘_5$	.473	$☿_5$	.477
$\frac{2}{3}$	$⊕_3$	.667	$♀_1$	.672
$(\frac{2}{3})^2$	$♂_5$	.772	$♀_5$	.774
$(\frac{2}{3})^2$	$⊕_5$	.475	$☿_5$	.477
$(\frac{2}{3})^2$	$♀_1$	.299	$☿_1$	.297
$(\frac{2}{3})^3$	Ψ_5	9.028	$♄_2$	9.078
$(\frac{2}{3})^3$ 2.	Ψ_3	9.558	$♄_3$	9.539
$(\frac{2}{3})^3$	$♁_2$	5.428	$𝔘_4$	5.427
$(\frac{2}{3})^3$	$𝔘_5$	1.635	$♂_4$	1.644
$(\frac{2}{3})^3$	$♂_1$	.388	$☿_3$	.387
$(\frac{2}{3})^3$	$⊕_3$	.296	$☿_1$	.297
$(\frac{2}{3})^4$	$♄_1$	1.725	$♂_5$	1.736
$(\frac{2}{3})^4$	$𝔘_4$	1.075	$⊕_5$	1.068
$(\frac{2}{3})^4$	$𝔘_1$	.965	$⊕_2$	.966
$(\frac{2}{3})^5$	$♄_4$	1.317	$♂_1$	1.311
$(\frac{2}{3})^5$	$𝔘_5$	.727	$♀_3$	.723
$(\frac{2}{3})^6$	a	5.197	$𝔘_3$	5.203
$(\frac{2}{3})^6$	$𝔘_4$	.476	$☿_5$	.477
$(\frac{2}{3})^7$	$♁_2$	1.072	$⊕_5$	1.068
$(\frac{2}{3})^8$	$♁_3$	.749	$♀_4$	.749
$(\frac{2}{3})^8$	$♄_4$	.390	$☿_3$	.387

$(\frac{2}{3})^9$	Ψ_2	.773	φ_4	.774
$(\frac{2}{3})^9$	$\odot_2$	.477	$\mathfrak{P}_5$	.477
$(\frac{2}{3})^{10}$	$\odot_2$	.318	$\mathfrak{P}_2$	.319
$\frac{1}{2}$	$\odot_5$	10.340	$\mathfrak{h}_5$	10.343
$\frac{1}{2}$	$\odot_4$	10.022	$\mathfrak{h}_4$	10.000
$\frac{1}{2}$	$\mathfrak{h}_4$	5.000	$\mathfrak{U}_2$	4.978
$\frac{1}{2}$	σ_2	.702	φ_2	.698
$\frac{1}{4}$	$\odot_5$	5.170	$\mathfrak{U}_3$	5.203
$\frac{1}{4}$	$\mathfrak{U}_3$	1.301	σ_1	1.311
$\frac{1}{4}$	σ_3	.381	$\mathfrak{P}_3$	.387
$\frac{1}{8}$	$\mathfrak{U}_4$	.678	φ_1	.672
$\frac{1}{16}$	$\mathfrak{U}_2$	.311	$\mathfrak{P}_2$	.319
$\frac{1}{32}$	Ψ_1	.929	$\oplus_1$	.932
$\frac{1}{32}$	$\mathfrak{h}_3$	.298	$\mathfrak{P}_1$	.297
$\frac{1}{64}$	Ψ_5	.476	$\mathfrak{P}_5$	.477

The list might be indefinitely extended by admitting a wider range of differences, as well as by various combinations of the four primitive dissociating factors. After rotation was set up, the centre of rotating inertia, to which Alexander first called attention,* asserted its influence, as may be seen by the following comparisons :

$\frac{1}{r}$†	Ψ_4	19.184	$\odot_3$	19.184
$\frac{1}{r}$	$\mathfrak{h}_1$	5.524	$\mathfrak{U}_5$	5.519
$\frac{1}{r}$	σ_4	1.040	$\oplus_4$	1.034
$\frac{1}{r}$	σ_3	.964	$\oplus_2$	.966
$\frac{1}{r}$	$\oplus_5$	.675	φ_1	.672
$\frac{1}{r}$	φ_4	.474	$\mathfrak{P}_5$	.477
$\frac{1}{r}$	φ_3	.457	$\mathfrak{P}_4$	.455
$\frac{1}{r^2}$	σ_5	.695	φ_2	.698
$\frac{1}{r^3}$	$\odot_5$	5.231	$\mathfrak{U}_3$	5.203
$\frac{1}{r^3}$	$\odot_3$	4.853	$\mathfrak{U}_1$	4.886
$\frac{1}{r^3}$	$\mathfrak{U}_5$	1.397	σ_2	1.403
$\frac{1}{r^3}$	$\mathfrak{U}_3$	1.316	σ_1	1.311

* *Smithsonian Contributions*, 280.

† $\frac{1}{r} = \sqrt{.4}$

$\frac{1}{r^3}$	σ_3	.385	$\mathfrak{P}_3$	.387
$\frac{1}{r^4}.2$	Ψ_2	9.514	$\mathfrak{h}_3$	9.539
$\frac{1}{r^4}$	$\mathfrak{h}_5$	1.655	σ_4	1.644
$\frac{1}{r^4}$	$\mathfrak{h}_3$	1.526	σ_3	1.524
$\frac{1}{r^4}$	$\mathfrak{h}_1$	1.398	σ_2	1.403
$\frac{1}{r^4}$	$\mathfrak{U}_1$	.782	$\mathfrak{P}_5$	.774
$\frac{1}{r^5}$	$\mathfrak{h}_3$	.965	$\oplus_2$	.966
$\frac{1}{r^6}$	$\odot_5$	1.323	σ_1	1.311
$\frac{1}{r^6}$	$\mathfrak{U}_2$	.319	$\mathfrak{P}_2$	.319
$\frac{1}{r^7}$	$\odot_3$	.776	$\mathfrak{P}_5$	.774
$\frac{1}{r^7}$	$\mathfrak{h}_3$	.386	$\mathfrak{P}_3$	.307
$\frac{1}{r^8}$	Ψ_4	.777	$\mathfrak{P}_5$	.774
$\frac{1}{r^8}$	$\odot_1$	.453	$\mathfrak{P}_4$	.455
$\frac{1}{r^9}.2$	Ψ_3	.973	$\oplus_2$	.966
$\frac{1}{r^9}$	$\odot_2$	.297	$\mathfrak{P}_1$	.297

If we take geometrical, instead of arithmetical means, and place $\frac{1}{2}a$ at Neptune's mean aphelion instead of his secular aphelion, the influence of orbital collisions on positions of intra-asteroidal planets becomes still more striking. For we find, as theoretical (T) and observed (O) values:

	O.		T.	(T-O). ÷ T.
$\mathfrak{U}_3$	5.203	$\cdot\frac{a}{n}$	5.223	+.004
σ_3	1.524	$(\frac{2}{3})^3\cdot\frac{a}{n}$	1.548	+.016
$\oplus_4$	1.033	$(\frac{2}{3})^4\cdot\frac{a}{n}$	1.032	—.001
$\mathfrak{P}_2$	.697	$(\frac{2}{3})^5\cdot\frac{a}{n}$	.688	—.014
$\mathfrak{P}_4$	.452	$(\frac{2}{3})^6\cdot\frac{a}{n}$	.459	+.015
Mean	1.209		1.213	+.004

Comparing the positions of inter-Uranian planets which are most correctly represented in the foregoing tables, and taking the geometrical means for the five positions of each planet, we find :

	O.	T.	(T-O) ÷ T.
♄	9.521	9.512	—.0009
♃	5.197	5.196	—.0002
♂	1.516	1.517	+.0014
⊕	.999	1.001	+.0021
♀	.722	.721	—.0013
☿	.380	.380	+.0001
Mean	3.567	3.567	+.0002

A similar closeness of accordance is shown by comparing the positions of the intra-Nepturian planets which appear to be most typical :

	O.			T.	(T-O) ÷ T.
☉$_3$	19.184	$\frac{1}{r}$	Ψ$_4$	19.186	+.0001
♄$_5$	10.343	$\frac{1}{2}$	☉$_5$	10.340	—.0004
♃$_4$	5.427	$(\frac{2}{3})^3$	☉$_2$	5.429	+.0003
♂$_3$	1.524	$\frac{1}{m^2}$	☉$_2$	1.524	+.0002
⊕$_2$	.966	$\frac{1}{r^3}$	♄$_3$	.965	—.0009
♀$_4$	.749	$(\frac{2}{3})^8$	☉$_3$	.749	—.0005
☿$_5$	.477	$(\frac{2}{3})^9$	☉$_2$	.477	—.0003
Mean	2.473			2.478	—.0002

The variation of the nucleal radius as the $\frac{3}{4}$ power of the atmospheric radius,* may furnish an explanation of results which seem to have been obtained nearly simultaneously, by Silas W. Holman (A. A. A. S. June 14, 1876 ; P. Mag, Feb., 1877 ; p. 81), and E. Warburg (Pogg. Ann. clix, 415 ; communicated 9th July, 1876). Holman concludes, from the results of a number of careful experiments, that the "viscosity of air increases proportionally to the 0.77 power nearly, of the absolute temperature, between 0° and 100° C." The extreme range of his results is .738 to .799. Warburg, from experiments both with hydrogen and with air, deduces the exponents between 20° and 100°, .76 for air (the extremes being .74 and .76), and "about $\frac{2}{3}$" for hydrogen (the extremes being .57 and .65). The closeness, the narrow range, and the mutual confirmation of these independent results, as well as the new analogy between molar and molecular forces, which seems to be indicated by the atmospheric exponents, are all interesting. The viscous particles, so far as they are affected by the same movements, may be compared to the rotating particles of a solid nucleus ; the thermal undulations, in a supposed æthereal medium, present a like analogy to the motions of an elastic atmosphere. The well known anomalies in the elasticity of hydrogen are in accordance with its viscosity. War-

* *Ante*, xiv, 305 *et. al.*

burg's extremes (hydrogen .57, air .76) seem to point towards secondary nucleal and atmospheric relations between air and hydrogen.

In my identification of the velocity of solar dissociation with the velocity of light,* although the conception of successive wave impulses seems most natural, it is by no means essential. If the pressure of the ultimate force is constant, the result is the same. The ratio of the velocity of dissociation to the velocity of perfect fluidity,† is approximately illustrated by Draper's estimate of the ratio between the temperature of glow (977° F., or 1436° from absolute 0°) and the temperature of fluidity (32° F., or 491° from absolute 0°; $1436 \div 491 = 2.9$). Here complete fluidity is compared with incipient glow. The ratio $\pi : 1$ would require an additional allowance of 107°, or about 7.5 per cent., for the difference between the temperature of complete and incipient glow. If the comparison were made at 0° F., we should have $1436 \div 459 = 3.13$.

The *vis viva* of terrestrial dissociation being equivalent to $\frac{1}{2}$ the *v. v.* of incipient planetary dissociation at the Sun,‡ the temperature ratio of water vaporization to dissociation furnishes another illustration of a similar character. Deville (C. Rendus, lxxxiv, 1259) quotes the estimates made by himself and Debray (2500°), and by Bunsen (2800°), of the temperature at which nearly half of the vapor of water is reduced to its elements, hydrogen and oxygen. The ratio 2800° : 100° is a very probable estimate of the ratio between solar and terrestrial superficial gravitation.

NOTE.—August 23, 1877. In consequence of a remark near the opening of the foregoing paper, Dr. Draper recently proposed that I should test some of my views by an examination of the solar spectrum. I accordingly undertook a preliminary investigation, which has already yielded the following results:

In the harmonic progression, $\frac{c}{n}, \frac{c}{n+a}, \frac{c}{n+2a}$, etc., let c = wave-length of Fraunhofer line A = 761.20 millionths of a millimetre; $n = 1.0153$; $a = .0918$; and we find the following accordances:

Numerator.	Denominators.	Quotients.	Observed values.
761.20	$n + a$	687.75	687.49 = B
	$n + 3a$	589.89	589.74 = D^1
	$n + 6a$	486.14	486.52 = F
	$n + 10a$	393.79	393.59 = H^1

The "observed values" are the wave-lengths, as determined by Dr. Wolcott Gibbs (Amer. Jour. Sci. [2] xliii, 4). The lines between A and B have not been studied sufficiently to fix their wave-lengths; it seems likely that $A \div n$ may be a *bright* line, and thus belong to the field of investigation which Professor Draper has so brilliantly opened. The greatest difference between the above theoretical and observed values, is

* *Ante*, xvi, 307, *et al.* † Ib. p. 305. ‡ Ib. p. 307-8.

less than four ten-millionths of a millimetre, and, therefore, very far within the limit of probable errors of observation.

My papers on planetary harmonies have shown that alternate planetary positions manifest the greatest simplicity of law, intermediate positions being modified by requirements of mutual equilibrium, which help to give stability to the system. The same thing seems to be true of the Fraunhofer lines. The "figurate" symmetry of the above divisor differences ($1\,a$, $3\,a$, $6\,a$, $10\,a$) is especially noticeable, and suggestive of my equation between the principal planetary masses:

(Neptune) $^{1}\times$ (Uranus) $^{3}\times$ (Jupiter) $^{6}\times$ (Saturn) $-^{10}=1$.

After finding this relation among the most important lines, I sought for traces of the "morning-star" music among the subordinate lines, with the following result: I have introduced Kirchhoff's scale-measurements, in order that the lines may be identified without the necessity of reference to Dr. Gibbs's papers.

Divisors.	Quotients.	Observed values.	Scale measurem'ts.
$n + 2\,a$	635.07	634.05	783.8
$n + 4\,a$	550.72	550.70	1306.7
$n + 5\,a$	516.42	517.15	1655.6
$n + 7\,a$	459.22	458.66	2436.5
$n + 8\,a$	435.12	435.67	2775.7
$n + 9\,a$	413.43	(413.76)	(?)

There is no single line corresponding to the harmonic denominator $n + 9\,a$. The bracketed number is the arithmetical mean between Kirchhoff line 2869.7 = 430.37, and H = 397.16. This again, may either indicate a *bright* line, or it may await future discovery for a true interpretation.

The equality, which I had previously pointed out, between the average limiting velocities of solar centrifugal and tangential dissociation, and the velocity of light, induced me to apply the same harmonic series to the solar system. In some of the papers on cosmical and molecular force, which I have had the honor of communicating to the society (Proc. Soc. Phil. Amer. vol. xiii.), I had taken steps in this direction, but they were comparatively feeble, for want of sufficient definite guidance. They had, however, shown very clearly, that, in ultimate physical generalizations, the study of elastic reaction is quite as needful as the study of centripetal action, and *vice versa*. One of the most important facts, in connection with such comparative study, is the variation of elastic density in geometrical ratio, when distance varies in arithmetical ratio. In making an operative application of the spectral harmonic series, the several terms should therefore be taken exponentially, and the greatest activity should be looked for at inter-nodes, and presumably nearly midway between successive nodes. The Sun's radius was naturally suggested as a fundamental unit.

The process of calculation is nearly as simple as Columbus's egg, but, on

account of its novel application, it may be well to give it in full. The common astronomical unit is Earth's mean radius vector; its value, in units of solar radius, is 214.86. The harmonic exponential numerator, is Neptune's mean radius vector, which is 30.03386 astronomical units, or $30.03386 \times 214.86 = 6453.06$ solar radii. The logarithm of 6453.06 is 3.809766; log. log. 6453.06 = log. 3.809766 = .580897. By the same method we find log. log. Uranus = .558210; .580897 — .558210 = .022687 = log. 1.0536. Uranus's mean radius vector represents, therefore, the 1.0536th root of Neptune's mean radius vector, and 1.0536 is the denominator of the first planetary fractional exponent. The first mid-nodal denominator, in the foregoing spectral-line series, between $A \div 1$ and $A \div (n + a)$ is $(1 + 1.1068) \div 2 = 1.0534$; the second mid-nodal denominator is $(n + a + n + 2a) \div 2 = 1.1527$; and so on, until we reach the sixth denominator, when, perhaps on account of great nebular condensation, the harmonic denominator-differences become $\frac{5}{4}$ of .0918, instead of .0918, bringing a second exact correspondence between the spectral and planetary denominators in the orbit of Venus. The following table contains all the figures that are required for the whole calculation:

Expon'l Den'rs.	Log. Den'rs.	Log. log. *r. vec.*	Log. *r.* I.	Log. *r.* II.	Theoretical.	Observed.
1.0534	.022593	.558304	3.61689	1.28473	19.263	19.184
1.1527	.061716	.519181	3.30576	.97360	9.410	9.539
1.2445	.094994	.485903	3.06128	.72912	5.359	5.427
1.3368	.126066	.454831	2.84991	.51775	3.294	?
1.4281	.154758	.426139	2.66771	.33555	2.165	?
1.5199	.181815	.399082	2.50658	.17442	1.494	1.524
1.6346	.213412	.367485	2.33070	T.99854	.997	1.000
1.7494	.242889	.338008	2.17775	T.84559	.701	.698
1.8641	.270469	.310428	2.04375	T.71159	.515	.510
1.9789	.296424	.284473	1.92519	T.59303	.392	.387

The log. logs., in the third column, are obtained by subtracting the logs. of the exponential denominators (column 2) from the log. log. of the exponential numerator (.580897). Column 4 contains the antilogs. of column 3; column 5 is column 4 reduced to logs. of Earth's mean radius-vector, by substracting log. 214.86 = 2.332155; column 6 contains the antilogs. of column 5. Column 7 gives the mean distances of Uranus, Saturn, Mars, Earth, and Mercury; the mean aphelion of Jupiter; the mean perihelion of Venus; and the arithmetical mean between Mercury's secular perihelion, and Venus's mean distance.

We are now prepared to find the significance of the remaining Fraunhofer lines, which is shown in the following table:

Line.	Wave Length.	Denominator.	Planetary Den'rs.	Theoretical Den'rs.
C	656.67	1.1590	1.1576 = Sat. p.*	
E	527.38	1.4434	Asteroidal.	
b	517.70	1.4704		$1.4740 = n + 5a$
G	431.03	1.7660	1.7640 = Ven. s.p.	
H	397.16	1.9166	1.9139 = Mer. a.	

* p., *mean perihelion;* s. p., *secular perihelion;* a., *mean aphelion.*

The following table gives a comparative view of the spectral and planetary series:

Spectral	Differences.	Planetary	Diff.
a 1.0000	$\frac{1}{6}\,a$	1.0000	$\frac{7}{12}\,a$
β 1.0150	a	$\frac{1}{2}\,(a+\gamma)$ 1.0534	$1\frac{3}{12}\,a$
γ 1.1068	a	$\frac{1}{2}\,(\gamma+\delta)$ 1.1527	a
δ 1.1986	a	$\frac{1}{2}\,(\delta+\varepsilon)$ 1.2445	a
ε 1.2904	a	$\frac{1}{2}\,(\varepsilon+\zeta)$ 1.3363	a
ζ 1.3832	a	$\frac{1}{2}\,(\zeta+\eta)$ 1.4281	a
η 1.4740	a	$\frac{1}{2}\,(\eta+\theta)$ 1.5199	$\frac{5}{4}\,a$
θ 1.5658	a	$\frac{1}{2}\,(\theta+\iota)+\frac{1}{4}\,a$ 1.6347	
ι 1.6576	a		$\frac{5}{4}\,a$
$\varkappa$ 1.7494	a	$\varkappa$ 1.7494	$\frac{5}{4}\,a$
λ 1.8412	a		
μ 1.9330	a	$\frac{1}{2}\,(\lambda+\mu)-\frac{1}{4}\,a$ 1.8641	$\frac{5}{4}\,a$
ν 2.0248	a	$\frac{1}{2}\,(\mu+\nu)$ 1.9789	$\frac{5}{4}\,a$
o 2.1166	a	$\frac{1}{2}\,(\nu+o)+\frac{1}{4}\,a$ 2.0936	$\frac{5}{4}\,a$
π 2.2084		π 2.2084	

In the fundamental harmonic denominators, it will be seen that $a = 6\,n$, and 6 is the figurate exponent of Jupiter in the equation of planetary masses. The value of n is the quotient of (Jupiter $\times$ perihelion radius-vector) by (Sun $\times$ solar radius). The significance of this quotient is obvious, on account of the preponderating influence of the two controlling members of our system. It becomes still more interesting upon examining the portion of the spectrum which represents Jupiter's most powerful reaction against solar action.

As the harmonic basis is Jupiter's *present* perihelion, it seems likely that there may be some changes in the relative positions of the spectral lines, with Jupiter's changing eccentricity. As this change is less than $\frac{1}{375}$ of one per cent. per annum, its influence cannot be detected by direct observation. But it may be worth while to institute careful comparisons between solar spectra taken at our perihelion, aphelion, perijove and apojove, in order to find whether the lines are modified in any way by Earth's position relatively to Sun and Jupiter.

CONTRIBUTIONS FROM THE LABORATORY OF THE UNIVERSITY OF PENNSYLVANIA.

No. XI.

On some Tellurium and Vanadium Minerals.

BY F. A. GENTH.

(*Read before the American Philosophical Society, August 17th*, 1877.)

Since the publication of my papers: "On American Tellurium and Bismuth Minerals," read before the American Philosophical Society, August 21, 1874, and "On Some American Vanadium Minerals," published in the American Journal of Science and Arts, July, 1876, I have made several observations which I believe to be worthy of being placed upon record.

1. NATIVE TELLURIUM.

Its occurrence at the Red Cloud Mine, where it is a comparatively rare mineral, has previously been mentioned. Recent developments in Colorado have furnished a number of new localities, in some of which it is found in considerable quantities and in peculiar varieties, associated with other very interesting minerals.

1. In Magnolia District, Boulder County, at the Keystone Mine and Mountain Lion Mine (which are working the same vein), also at the Dun Raven Mine, it occurs in crystals and crystalline masses. The crystals are usually small and very indistinct, much distorted, cavernous, and the prismatic planes longitudinally, deeply striated; often surrounding quartz crystals; occasionally, besides the planes of the hexagonal prism, rhombohedral and basal planes can be observed; it is also found in columnar masses and, disseminated in grains, through other minerals.

Sometimes it forms sheets and thin plates between the ores, which consist of quartz, mixed with a peculiar greenish vanadiferous mineral (? roscoelite), coloradoite, calaverite, pyrite, &c. This variety has often the appearance of "slickensides," and is sometimes in masses as thin as paper, occasionally, however $\frac{1}{8}$ of an inch in thickness; it is dark grey, on a fresh fracture greyish white; it is finely granular and of very little lustre. The specific gravity of the pure mineral (making allowance for the admixed quartz) was found to be 6.275.

The analysis gave, after deducting 8.90% of quartz, as follows:

Au	=	0.60
Ag	=	0.07
Te	=	96.91
V_2O_3	=	0.49
FeO	=	0.78
Hg, Al_2O_3, MgO, K_2O, &c.	=	1.15
		100.00

2. A very peculiar variety of native tellurium occurs at the Mountain Lion Mine, where it is associated with quartz and imbedded in a greenish, clayey mineral. It has been discovered by Mr. Theodore Berdell, of Boulder, Colorado, who very kindly furnished me with this and most of the other specimens from this mine.

He distinguished it as "lionite." It occurs in flat, plate-like masses of $\frac{1}{8}$ to $\frac{3}{16}$ of an inch in thickness; it has a dark grey color, very little lustre, and a somewhat columnar structure at right angles with the plates; brittle. H = 3; Sp. Gr. = 4.005.

Examined with a strong magnifying glass it shows numerous air-holes, but otherwise seems to be quite uniform. It looks very much as if it had been melted and not unlike a "matte." The analyses showed an admixture of a very large quantity of silicic acid and silicates, and it is impossible to conceive, how such heterogeneous substances could have formed such a uniform material. It can, of course, not be considered as a species, but only as a variety of native tellurium. The analyses gave:

		I.	II.
Au	=	1.38	1.53
Ag	=	0.25	0.25
Te	=	55.86	55.54
SiO_2	=	34.72	35.91
Al_2O_3, Fe_2O_3	=	6.15	6.14
MgO	=	0.17	0.19
CaO	=	0.48	0.26
		99.01	99.82

3. Very minute, but brilliant, crystals of native tellurium, in combinations of an hexagonal prism and pyramid have been found in cavities of quartz at the Smuggler Mine, Ballerat District, Boulder County, Colorado. They are mostly distorted and have the appearance of rhombic prisms, from the enlargement of two opposite hexagonal planes at the expense of the four others. The hexagonal planes are deeply striated, and the pyramidal ones rarely well developed. The ore from the deeper part of the vein consists largely of native tellurium in a granular variety, associated with sylvanite, coloradoite, &c. The analyses of it, after deducting in the first 28.04% of quartz, and in the second 65.21% of quartz, gave:

		I.	II.	
Au	=	3.40	2.18	
Ag	=	1.69	1.15	
Hg	=	1.07	1.34	
Cu	=	0.51	0.43	
Pb	=	0.74	1.02	
Fe	=	0.12	0.18	
MgO	=	0.12	0.06	
Te	=	92.29	[93.64]	by diff.
		99.94	100.00	

4. The largest quantities of native tellurium have been observed at the John Jay Mine, in Central District, Boulder County, Colorado. I was informed that masses of 25 pounds in weight had been found there. I am indebted to the owner, Mr. A. J. Van Deren, for very fine specimens, which were taken from his mine at a depth of 30 to 35 feet.

The tellurium is more or less mixed with quartz, it is granular to columnar in structure and of a color between tin-white and lead-grey. In the cavities and on the surface are rarely found tellurous oxide or tellurite, in minute crystals.

A very pure specimen, after the deduction of 14.08% of quartz, contained:

Au	=	1.04
Ag	=	0.20
Zn	=	0.32
Fe	=	0.89
Te	=	97.94
		100.39

2. Hessite.

My friend, Mr. August Raht, wrote me from Utah on the 20th February, 1877, that, in testing an ore from the Kearsage Mine, Dry Cañyon, Utah, he found it to contain large quantities of tellurium, and afterwards, in analyzing a pure piece before the blow-pipe, obtained:

Ag	=	58.790
Au	=	0.103

It is evidently hessite, almost free from gold, similar to that which I described from the Red Cloud Mine, Colorado, where it has been *once* found as a very great rarity.

3. Coloradoite, a new Mineral.

I have mentioned the occurrence of telluride of mercury, which I have called "coloradoite" already at the meeting of the American Philosophical Society of October 20th, 1876. I observed it amongst ores from the Keystone Mine, Magnolia District, received for examination by the late Dr. W. H. Wenrich, of Denver. It also occurs at the Mountain Lion Mine; a specimen of ore, for which I am indebted to Commodore Stephen Decatur, Centennial Commissioner of Colorado, and which was found at the depth of 8 or 10 feet at the Smuggler Mine, Ballerat District, proved also to be this interesting species.

Not crystallized, without cleavage; massive, somewhat granular; that from the Smuggler inclining to an imperfectly columnar structure. Fracture uneven to subconchoidal. Hardness about 3; Sp. Gr. = 8.627—(pure mineral, after making allowance for the admixture of native tellurium and quartz). Lustre metallic; color iron-black, inclining to grey,

with a very faint purplish hue; frequently tarnished with purplish, blue and green colors.

B. B. in a tube slightly decrepitates, fuses and yields an abundant sublimate of metallic mercury, also drops of tellurous oxide and, next to the assay, metallic tellurium. On charcoal it gives a greenish flame and white sublimate. Soluble in nitric acid. Very rare. At the Keystone and Mountain Lion Mines, associated with native tellurium and quartz; at the Smuggler Mine it is often mixed with native gold, resulting from sylvanite, more or less completely decomposed, native tellurium and tellurite. It is probable that the admixture of sylvanite produces its columnar structure.

I have endeavored by mechanical means to separate, as much as possible, the pure coloradoite from the associated minerals, but was not successful.

The best selected fragments from the Smuggler were first digested for some time with ammonic hydrate to remove the tellurite; the remaining impurities are gold, sylvanite and quartz.

The analyses of the heaviest portions from the Keystone Mine, which have been obtained by levigation, show a higher percentage of mercury, the lighter a larger admixture of tellurium. The results leave no doubt that the pure coloradoite has the composition: Hg Te, corresponding with that of Cinnabar and Tiemannite, and containing:

Hg	=	60.98
Te	=	39.02

The specimens from the Keystone Mine, after deducting quartz and gold, gave the following results:

	I.	II.	III.	IV.	V.
Quartz and Gold	= [28.50]	— [46.83]	— [25.18]	— [8.46]	— [20.72]
Hg	= 56.33	— 52.28	— 51.48	— 49.80	— 45.63
Te	= 43.81	— 42.95	— 44.25	— 46.74	— 50.05
Al_2O_3, Fe_2O_3		= 2.44			
V_2O_3		= 0.70			
MgO	= traces	= 0.11	not determined.		
CaO		= 0.84			
K_2O, Na_2O					
	100.14	99.32			

SMUGGLER MINE.

		VI.		VII.
Quartz	=	[2.90]	—	[3.05
Au	=	3.46	—	7.67
Ag	=	2.42	—	7.18
Hg	=	55.80	—	48.74
Cu	=	trace	—	0.16

SMUGGLER MINE—*Continued.*

		VI.		VII.
Zn	=	trace	—	0.50
Fe	=	1.35	—	0.92
Te	=	36.24	—	34.49
		99.27		99.66

I. Contains 92.38 % coloradoite and 7.76 % native tellurium.
II. " 85.74 " " " 9.49 " " "
III. " 84.43 " " " 11.30 " " "
IV. " 81.67 " " " 14.87 " " "
V. " 74.83 " " " 20.85 " " "
VI. " 91.51 " "
VII. " 79.93 " "

When I first received the mineral from the Smuggler, the preliminary examination of it made me think that gold and silver might be essential constituents of the same; the subsequent analyses showed them to be admixtures. The specimen which furnished the material for investigation, having come from near the surface, contained such a quantity of tellurite, that I was anxious to analyze the ore from the undecomposed part of the vein, and, for this reason, delayed the publication of my results for over six months. After a great deal of trouble, I secured a specimen, but unfortunately, it proved to be almost pure native tellurium (of which I gave the analyses above), I. containing an admixture of only 1.75 %, and II. of 2.20 % of coloradoite.

4. Calaverite.

I established this species nine years ago, on very minute quantities found, associated with petzite, at the Stanislaus Mine, Calaveras County, California; then I observed it again as a great rarity at the Red Cloud, and published an analysis made with only 0.1654 grammes. From Mr. Berdell I received a short time ago a specimen, which furnished me with more than five grammes of calaverite, mixed only with a small quantity of quartz and coated with ? roscoelite. A reëxamination of this rare species was therefore highly desirable.

In very minute, imperfect crystals, resembling rhombic or monoclinic forms, but too indistinct for a more exact determination; cleavage indistinct; massive granular; fracture uneven.

H = 2.5; Sp. Gr. (of the pure mineral, less quartz), = 9.043. Pale bronze yellow; brittle. In thin seams and disseminated in quartz and gangue-rock at the Keystone and Mountain Lion Mines.

The analyses gave, after deducting in I. 4.96% of quartz, and in II. 4.00% of quartz:

		I.		II.		Calculated.
Au	=	38.75	—	38.91	—	39.01
Ag	=	3.03	—	3.08	—	3.06
Te	=	57.32		——	—	57.93
V_2O_5	=	0.05		——		
FeO	=	0.30		——		
Al_2O_3, MgO, &c., not det'd.	=	0.55		——		
		100.00		——		100.00

These analyses give the ratios of (Au Ag): Te = 1 : 2; Au : Ag = 7 : 1.

The composition of calaverite, corresponding with the above analyses, is therefore:

$$(\tfrac{7}{8}\ \mathrm{Au}\ \tfrac{1}{8}\ \mathrm{Ag})\ \mathrm{Te}_2.$$

In "Nature," of March 8th, 1877, it is stated that at the February meeting of the Hungarian Geological Society, Professor Krenner announced the discovery at Nagy-Ag, in Transylvania, of a pure *Telluride of gold*, in a crystalline state, which he calls "bunsenite" (a name already given by Prof. J. D. Dana, in 1868, to the niccolous oxide from Johanngeorgenstadt, described by Bergemann). As I have no access to the original publication, I am unable to decide whether it is different from calaverite; perhaps it is a variety even more free from silver than those of this country.

5. Tellurite.

Already in 1842, Petz observed tellurous oxide, associated with native tellurium at Facebay and Zalathna in Transylvania. It has never been observed from any other locality, until I have lately noticed it with tellurium at the Keystone and Smuggler Mines, but especially in cavities and fissures of the native tellurium of the John Jay Mine, where it is found in minute white, yellowish-white and yellow crystals, mostly prismatic, often longitudinally striated, isolated or aggregated into bundles; a few of the white crystals are acute rhombic pyramids. Cleavage eminent in one direction.

Lustre vitreous inclining to resinous, on the cleavage plane adamantine.

Readily soluble in ammonic hydrate; the solution contains only tellurite of ammonium; the composition of tellurite is therefore, as Petz had already suggested, tellurous oxide = TeO_2.

6. Magnolite, a new Mineral.

This highly interesting mineral is the product of the oxydation of coloradoite. It occurs very rarely with native mercury in the upper, decomposed part of the Keystone Mine, associated with quartz, limonite and psilomelane.

In exceedingly fine needles, which under the microscope appear in bundles or tufts, sometimes radiating; some of the groups seem to have crystallized around a globule of mercury, which latter, in breaking the specimen, has fallen out, leaving a round empty space in the centre of the crystals. Color white; lustre silky.

Readily soluble in *very dilute* nitric acid, the solution yielding a precipitate of Hg Cl by hydrochloric acid; the mineral is also soluble in hydrochloric acid, the solution contains $HgCl_2$ and $TeCl_4$, which proves that its composition is "mercurous tellurate" $= Hg_2TeO_4$. —

$$Hg_2TeO_4 + 8HCl = 2HgCl_2 + TeCl_4 + 4H_2O$$

The mineral is also blackened by ammonic hydrate.

Name after "Magnolia" District.

7. Ferrotellurite, a new Mineral.

A crystalline coating upon quartz, associated with native tellurium. Under the microscope it appears in very delicate tufts, sometimes radiating or, when in cavities, as very minute prismatic crystals of a color between straw and lemon-yellow inclining to greenish-yellow.

Insoluble in ammonic hydrate; some of the mineral, which had been treated with ammonic hydrate for the purpose of removing the tellurous oxide present, was dissolved in hydrochloric acid. The solution contained tellurous oxide, ferric oxide, and a trace of niccolous oxide; the mineral is therefore probably a ferrous tellurate $= FeTeO_4$, hence the name. The quantity at hand is too small for a fuller investigation.

It occurs at the Keystone Mine, Magnolia District, Colorado, associated with native tellurium, tellurite, and a peculiar iron sulphide, in which a part of the sulphur is replaced by tellurium. A preliminary examination of it gave Fe = 41.01, Ni = 0.72, Te = 4.06 and S = 41.73 = 87.52. The material for analysis was slightly oxidized, but the difference of 12.48 % is too great to be covered by this. I shall repeat the analysis, if ever I should succeed to get this mineral again.

8. Roscoelite.

It will be remembered, that almost simultaneously, Prof. H. E. Roscoe and I investigated the mineral, which now bears his name, his paper having been received by Royal Society on May 10th, 1876, (Proc. Royal Soc. XXV, 109.) whilst mine was written and sent to the editors of the American Journal of Science on May 16th, 1876.

I regret to say that in some of the essential points our results do not agree.

From the nature of the material and the information received from Dr. James Blake of San Francisco, no doubt can exist that, that, which he had sent to me, was as good and pure as it could be obtained. In my examination (Am. Journ. of Sc. [3] XII, 32) I showed that even the apparently purest scales, selected with the greatest pains, were not altogether free from admixtures. With the greatest difficulty I obtained enough of almost

pure scales (containing only 0.85 % of quartz, gold, &c.) to make *one* analysis, which, as it was made with the greatest care, must be a very close approximation of the truth. The material of the other analyses was far more contaminated, and the results were given merely for comparison and to show the influence of the admixtures upon the analyses.

From Prof. Roscoe's analyses it does not appear that he attempted to separate the impurities by chemical means, and thus he gives the composition of the whole mixture.

He assumes the vanadium to be present as pentoxide, the iron as ferric oxide, the manganese as manganic oxide, the two latter as replacing alumina; and magnesia, lime and soda as replacing potassium oxide.

As I have made a direct determination of the state of oxydation of the vanadium, I can say *positively* that, if any, only the smaller portion of the vanadium is pentoxide. I found the composition of the vanadium oxide to be $V_6O_{11} = 2\,V_2O_3,\ V_2O_5$; but as it was obtained after allowing for the oxydation of ferrous into ferric oxide, and as the quantities of ferrous oxide have been found to vary from 1.67 to 3.30 %, it is not impossible that an insufficient quantity of oxygen has been deducted, and that the whole of the vanadium is present as V_2O_3.

Pure roscoelite contains no manganese; in Prof. Roscoe's analyses 0.85 — 1.45 % of manganic oxide have been found, which confirms my opinion that his material was not pure; but what is most astonishing to me is the very low per centage of silica which he finds.

From his analyses he calculates a formula, and from this the per centage composition, which, however, is far from corresponding with his analyses, as for instance:

Silica found	= 41.25,	calculated	= 41.18
Potassium oxide found	= 8.56,	"	= 14.24

I had not calculated any formula from my analyses, being in hope that I may yet be able to procure this interesting mineral in a still purer state for further investigation. For comparison I will insert my analysis (*a*) which certainly closely represents the true composition of Roscoelite, and will add the formula corresponding with the same, with this alteration however, that I consider all the vanadium as V_2O_3. It contains, after deducting 0.85 % of quartz, gold, &c.:

		Found.		Calculated.
SiO_2	=	47.69	—	49.33
Al_2O_3	=	14.10	—	14.09
V_2O_3	=	20.56	—	20.62
FeO	=	1.67	—	1.64
MgO	=	2.00	—	1.83
Li_2O	=	trace.	—	—
Na_2O	=	0.19	—	—
K_2O	=	7.59	—	7.55
Ignition	=	4.96	—	4.94
		98.76		100.00

The analysis agrees with the formula :

$$\overset{I}{R}_2\ \overset{II}{R}\ \overset{VI}{R}_2\ Si_{12}\ O_{32} + 4\,H_2O$$

$$\overset{I}{R} = K$$

$$\overset{II}{R} = Mg : Fe = 2 : 1$$

$$\overset{VI}{R} = \text{Al} : \text{V} = 1 : 1$$

or, $K_2\ (MgFe)\ (\text{Al V})_2\ Si_{12}\ O_{32} + 4\ H_2O$

as will be seen from the calculated per centage.

Green Mineral from Colorado, ? Roscoelite.

A mineral which is closely allied to, and which may be only a variety of roscoelite, occurs in Magnolia District, Boulder County, Colorado, especially at the Keystone and Mountain Lion Mines. It has not yet been found in a pure state, but only as the coloring matter of quartz which, at some parts of these mines, forms the gangue rock of the veins. The purest, which I have seen, was in the form of a thin, earthy coating of a greyish-green to olive-green color upon calaverite.

Mr. Theodore Berdell, to whom I am indebted for specimens has repeatedly called my attention to this green quartz, and mentioned that it is always very rich in precious metals.

For the examination of the green mineral, which colors the quartz, about 150 grammes of the latter were powdered and separated from the metallic particles by levigation, as near as possible.

The metallic particles were found to be a mixture of native tellurium and calaverite, containing :

Native tellurium	=	55.4 %
Calaverite	=	38.5 "

The green quartz, which was left, was found on an average of four experiments to contain :

Quartz	=	79.38 %
Tellurium	=	1.05 "
Gold	=	0.03 "
		80.46 %

This leaves for the "*green mineral*" about 19.5 % which was adopted as the basis for calculation of the results of the analyses.

In two experiments, made for the purpose of ascertaining the state of oxydation of the vanadium, it was found that after making due allowance for the oxydation of ferrous into ferric oxide by potassium permanganate, the oxygen in the vanadium pentoxide to that of the vanadium oxide in the mineral was : 5 : 3 and 5 : 2.88, which leaves no doubt that the vanadium was present as V_2O_3.

The water, which was present in small quantity, could not be determined with accuracy, because, on ignition, a portion of the tellurium went

off as hydrogen telluride. In one experiment with the mixture of quartz and green mineral 1.24% was found, in a second 0.75—*both are too high.*

The following are the results of the analyses of the green mineral, after deducting quartz, &c.:

	I.	II.	III.	IV.	V.	Av'ge.
SiO_2 =	57.15	55.77	——	57.31	——	56.74
Al_2O_3 =	19.94	——	——	19.46	19.46	19.62
V_2O_3 =	8.44	——	7.37	7.79	7.51	7.78
MnO =	trace	——	——	——	——	trace
FeO =	3.51	——	4.52	——	3.51	3.84
MgO =	2.87	——	2.49	2.52	——	2.63
Li_2O =	trace	——	——	——	——	trace
Na_2O =	0.94	——	——	——	——	0.94
K_2O =	8.11	——	——	——	——	8.11
H_2O =	not det.	——	——	——	——	not det
	100.96					99.66

The formula which corresponds nearest to the average analysis is:

$$\overset{I}{R}_4\ \overset{II}{R}_3\ \overset{VI}{R}_3\ Si_{24}\ O_{62} + xH_2O$$

$$\overset{I}{R} = Na : K = 1 : 5$$

$$\overset{II}{R} = Mg : Fe = 5 : 4$$

$$\overset{VI}{R} = \text{Al} : \text{V} = 4 : 1$$

or, $$(NaK)_4\ (Mg\ Fe)_3\ (\text{Al}\ \text{V})_3\ Si_{24}\ O_{62} + xH_2O$$

Doubling, for the sake of comparison, the formula of roscoelite we have:

$$K_4\ (Mg\ Fe)_2\ (\text{Al}\ \text{V})_4\ Si_{24}\ O_{64} + 8\ H_2O;$$

this seems to prove that the green mineral accompanying the tellurium ores of the Keystone and Mountain Lion Mines is, although it may be a new species, is more probably a *variety of roscoelite,* in which *a great portion of the vanadium is replaced by aluminium.*

9. Volborthite.

The Siberian volborthite has never been analyzed.

Having observed in an experiment which I made with a few fragments from Woskressenskoi, in the Government Perm, in Ural, received from my friend, Prof. Geo. J. Brush, the presence of barium, I communicated this result to him, when he immediately, with his usual great liberality and kindness, placed at my disposal for a fuller investigation, all he had. I give the results, imperfect as they may be, because they may induce others, who have better material for investigation, to repeat the analyses.

The mineral occurred as a crystalline coating on the grains and pebbles of quartz, and in the cavities of an argillaceous conglomerate; it appeared to be very pure, of a siskingreen to a greenish yellow color, and of a pearly lustre.

As it was an impossibility to pick out the volborthite, the whole mass was crushed, merely to separate the grains of the conglomerate. These being very little acted upon, the mixture was treated with *very dilute* nitric acid, which dissolved the vanadate, and left the bulk of the conglomerate almost untouched; the latter was thrown on a tared filter, washed, dried and weighed. The amount of water in it was afterwards determined by ignition. In a separate portion of the mixture the total amount of water was also determined.

Different quantities gave 81.49 and 88.43% of insoluble residue, with 2.18 and 2.15 water. The total water was found in one sample to be 6.30%, and the ignited insoluble residue 83.74%, which would give for the *not* ignited residue 85.55%, and 14.45 soluble substances with 4.49 water or, 31.09%, which is a close approximation to the real quantity in the soluble portion.

The results of the analyses of the soluble portion, to which I add the calculated percentage of volborthite corresponding to the formula given below, are as follows:

		I.		II.		Calculated.
Si_2O_2	=	1.38	—	1.36	—	——
Al_2O_3	=	4.45	—	4.78	—	——
Fe_2O_3	=	1.77	—	0.45	—	——
MgO	=	3.01	—	1.42	—	——
CuO	=	34.04	—	38.01	—	38.41
CaO	=	4.29	—	4.49	—	6.77
BaO	=	4.29	—	4.30	—	6.17
V_2O_5	=	13.62	—	13.59	—	19.63
H_2O (by diff.)	=	[33.15]	—	[31.60]	—	29.02
		100.00		100.00		100.00

Considering silica, alumina, ferric oxide, magnesia and a portion of the water as impurities, and assuming the Woskressenskoi volborthite to be a combination of vanadates of barium, calcium and copper, with hydrate of copper and water of crystallization, we arrive at the following formula, closely agreeing with the analyses:

$$\text{Volborthite} = (\tfrac{1}{8}\ \text{Ba}\ \tfrac{3}{8}\ \text{Ca}\ \tfrac{4}{8}\ \text{Cu})_3\ V_2O_8 + 3\ \text{Cu}\ H_2O_2 + 12\ H_2O.$$

It will be seen that volborthite is closely allied to psittacinite (Am. Journ. Sc. [3] XII., 36), the formula of which I give for comparison:

$$\text{Psittacinite} = 2\ (\tfrac{3}{4}\ \text{Pb}\ \tfrac{1}{4}\ \text{Cu})_3\ V_2O_8 + 3\ \text{Cu}\ H_2O_2 + 6\ H_2O;$$

the difference being that the latter mineral contains twice as much $R_3V_2O_8$ and half as much water of crystallization; and lead in the place of barium, calcium, and a portion of the copper.

UNIVERSITY OF PENNSYLVANIA,
PHILADELPHIA, August 1st, 1877.

The Flow of Water Through an Opening in a Pierced Plate.

By Robert Briggs.

(*Read before the American Philosophical Society, August* 17, 1877.)

At the meeting of the Society on the 3d of November, 1876, I presented an hypothesis of the origin of the form of the *vena contracta* under certain conditions stated in the paper then offered. It was shown that on the assumption that the efflux occurred from the layer or strata of water under greatest pressure of water column, at the maximum velocity due to that column, the least section of the vena contracta would have half the area of the opening of efflux, provided the effect of frictional adhésion of the water to the bottom of the vessel and the effect of the internal friction or viscosity of the water were not considered. And it was noticed that the effect from these causes *tended* to enlarge the least section of the vein and increase the quantity of effluent water.

Referring to the words of the paper: "If however there is admitted to exist a certain adhesion to the bottom of the vessel or to the surface or the edges A A, so that the velocity of a particle on A B is less than that fully due to the head; the surface (d) would then become larger than $\frac{1}{2}$ D, the dimension C A would be properly increased to give a corresponding area of efflux, and the conoid Z would also have such contour as would permit the uniformity of flow of each and every particle of the liquid at unchanged velocity, in any section of the vena contracta transverse to the flow.* This increase of dimension of the cross section d, and the effect of the descending pencil in accelerating the flow through it, can be taken as sufficient to account for Weisbach's observed value of d = 0.8D, and the position of the plane of least section will be found at about $\frac{1}{4}$ D below the orifice as has been before quoted."

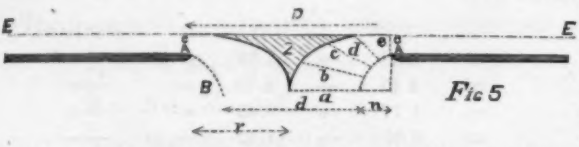


Fig 5

A further illustration of this subject can be instituted by accepting the observed value of the least section of *vena contracta*, which is found to be 0.64D in place of the hypothetical one of $\frac{1}{2}$ D, and by deducing the form of the effluent vein backwards to the strata of water under greatest pressure. Thus, let it be supposed that Fig. 6 represents (as in Fig. 5) an opening in a thin plate, guarded or protected by a Disc Z, of such contour and so placed that a current flowing towards the opening shall obtain the maximum velocity due to the head, and be diverted from its horizontal to the vertical direction without change of velocity of any particle of the current. The contour of the vena contracta from

Fig. 6

the edge of the aperture to the plane of least section is taken to be an arc of a circle—the internal surface of a segment of a ring. Let D be the diameter of the opening in the plate. Suppose d, the diameter of the least section of the *vena contracta*, to have the value given by observation, d = 0.8D. Then following the previous conditions of form of the conoid Z we have, the diameter of the Disc = D_1 = 1.13137D, and the radius of the arc of contour = n = 0.16569D. It will now be observed that the line of the arc of contour, if it is continued within the opening to supposed point of horizontal efflux—the circle of periphery of the disc, gives a strata of water f (shown more distinctly in Fig. 7), which is cut off from the effluent stream. This strata has its greatest thicknesss of f = 0.01358D. These suppositions place the plane of least section = 0.152D below the opening.

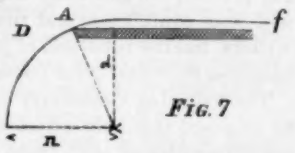


Fig. 7

In Fig. 8 will be seen similar delineation of the contour of the *vena contracta*, and the lines of the current of maximum constant velocity, as modified by placing the plane of least section at its observed position, or 0.25D, below the opening in the plate. The contour of the *vena contracta* is here depicted as an arc of an ellipsis which has 0.166D for its minor radius and 0.275D nearly for its major one, which will approximate closely to the true parabolic form as suggested in the first paper. The thickness of the film or strata f which represents the resistance arising from friction of water against the bottom and at *the edge* of the aperture now becomes about 0.025D. The angle α which the current makes with the edge of the aperture becomes about 35°.

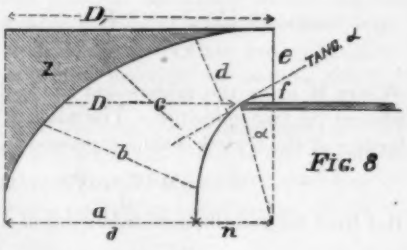


Fig. 8

If these suppositions are correct, a re-entering mouth-piece, shaped to conform to the upper part of the elliptical arc would give the same contour and sections to the *vena contracta* as that now found to proceed from free discharge at a plain aperture. It would seem also from the tenor of this discussion that by substituting a re-entering curve at A fig. 7, making the bottom of the vessel to conform to a reversal of the curve A f, giving the *reversed* elliptical arc a at the edge of the orifice, so that the tangent of the curvature upwards at the edge should be about 35°, we should then obtain the theoretic least section from a frictionless horizontal surface of = half the area of the opening. And that such a form would be equally effective with the re-entering tube of Mr. Froude, in giving the current at the edge of the aperture its horizontal direction of least resistance accompanied by the greatest liquid pressure.

The Deviating Forces of an Unsymmetrically Balanced Fly-wheel.

Mr. Briggs mentioned that he had not found in the text books of applied or practical Mechanics—Morin, Rankine, Weisbach, Fairbairn or others—any proper consideration had been given to the strains on the axis of a fly-wheel, which, correctly balanced with regard to the gravity of its masses, and also in the plane of rotation, yet without symmetry of position or mass of the balanced parts, is then accelerated or retarded to meet the usual requirements of a regulator of power. The fact that a fly-wheel must be balanced in one plane to run without vibratory effect at any given speed and when thus balanced the centrifugal forces of the parts will be in equilibrium and the axis permanent is fully stated by all recent writers, but the condition of permanency of axis when an unsymmetrically balanced fly-wheel gives out or absorbs force has not been discussed.

The following elementary case shows the proposition distinctly: Let it be supposed that a fly-wheel were formed of a pair of unequal weights at the extremities of arms (radii) of such length as will place the axis in the centre of gravity of the system, thus:

Where M m = the masses and r R = the radii. Let V_1, V_2 and v_1, v_2 represent the two velocities. The admitted energy from the change of velocities of the masses is thus expressed by the equation—

$$F = \left[M\,(V_1^2 - V_2^2) + m(v_1^2 - v_2^2)\right] \div 2g \qquad (1)$$

But from the condition of balancing $m = M\frac{r}{R}$; $v_1 = V_1\frac{R}{r}$; and $v_2 = V_2\frac{R}{r}$

$$\therefore\ F = \left[M\,(V_1^2 - V_2^2) + M\tfrac{r}{R}\left[V_1^2\left(\tfrac{R}{r}\right)^2 + V_2^2\left(\tfrac{R}{r}\right)^2\right]\right] \div 2g \qquad (2)$$

$$F = M\left[\left(1 + \tfrac{R}{r}\right)(V_1^2 - V_2^2)\right] \div 2g \qquad (3)$$

Showing that the ratio of force given out by the two halves of the fly-wheel under any change of velocity, during any instant of time, will be unity, and the axis be in equilibrium, when $1 = R \div r$ and in no other case, and the masses and velocities become equal in the same case.

This condition of unsymmetrical balancing of fly-wheels is by no means an unusual one. The castings of fly-wheels of steam engines and more especially of pulleys for transmission of force which act generally more or less as fly-wheels, are rarely of such uniformity as not to require balancing, —nearly always done on the rim of the wheel, regardless of point of inequality, which is more frequently in the arms than in the rim.

Perhaps the most striking instance is the case of the vertical blowing engine, where the whole weight of the pistons, crossheads and rods rests upon crank pins inserted in the arms of two fly-wheels at points from one-fourth to one-third the radii of the rim, which weight is counteracted by a suitable load at the rim opposite the crank pins. It is then found that much less load is needed to give comparative steadiness of motion than

what would be required to balance the parts, and that the blowing engine must be balanced to run at a given speed and thus be liable to definite changes of motion of the fly-wheel each stroke. In all steam engines with single cylinders it must be recognized that during an instant of the stroke, the fly-wheel must, solely and unaided, maintain the speed and give out the whole power of the engine *by retardation*, while in most engines, during a considerable portion of the stroke, the fly-wheel is aiding, or assisting to impel, the shaft of transmission ; of course receiving a corresponding impulse from other portions of the same stroke.

The unbalanced forces which result from changes of speed of rotation of these unsymmetrical wheels, are transformed into pressures at the axes and have to be sustained by the bearings and resisted by the frame works which carry or support the same, in addition to any strain, proceeding from the mechanism employed in giving rotation or in transmission of power. As pressure or load upon the bearings, the increment of heat derived from friction may cause the total heat to surpass the limit of dispersion in cases where the direct weight of the fly-wheel, approach, as they frequently do, the maximum load of practical endurance on the bearing surfaces. The apparently unaccountable heating of some fly-wheel bearings, where the absolute pressures from load or work are not so great as to cause heating, has been noticed by all practical mechanics, and the considerations now presented offer a reasonable hypothesis in explanation.

In Mahan's Moseley's Mechanics will be found some mathematical investigations leading in this direction, see appendix notes D and E, but a study of these forces and an application of the theorem to the special case of a fly-wheel regulating force or power is needed to complete the theory of practical mechanical construction.

Description of the Wilcox Spouting Water-Well.

By Chas. A. Ashburner, M. S., Assistant Geological Survey.

(*Read before the American Philosophical Society September* 21, 1877.)

The Wilcox Spouting Water-Well for the last nine months has attracted considerable attention, from the immense columns of water and gas which are periodically (every seven minutes) thrown up into air to a height of from 85 to 115 feet. The well is located in the valley of West Clarion Creek, just north of the southern boundary of McKean County, Pennsylvania, and five miles north of Wilcox, a station on the Philadelphia and Erie Railroad 104 miles east of the City of Erie.

The history of the well may be briefly stated as follows :

The Wilcox Well No. 1, or the old Adams Well, was drilled in 1864 (?)

to a depth of 1618 feet, and afterwards continued to a depth of 1785 feet,* where the tools which still remain in the hole, were lost.

The elevation of the top of the conductor above the railroad bridge at Wilcox is 120 feet or 1629 feet above the mean level of Atlantic Ocean. †

The well was drilled "wet," that is, no effort was made to keep the water encountered in the upper part of the hole from following the drill. Great difficulty was experienced in drilling on account of a heavy water vein which was struck at 60 feet depth. This was more particularly the case after the gas veins at 1200 and 1600 feet respectively were met. The water would flow into the hole on top of the gas which it would confine until the pressure of the latter became so great that a huge column of the water would be thrown out of the hole to the annoyance of the drillers. This occurred periodically.

After the tools were lost the upper 400 feet of the well was cased with a four inch casing having a water packer or seed bag attached to its lower end, effectually excluding the water and rendering the hole practically dry.‡

The well was then tubed and it is reported that as much as 100 barrels of oil was pumped and shipped to market; but on account of the great expense of procuring the petroleum, the hole was finally abandoned and the gas allowed free escape into the open air. The gas was afterwards fired and the derrick burned. Three or four years ago a wooden plug was inserted into the casing, which only permitted a partial escape of the gas.

About the beginning of the year 1876, when Well No 2 was started 900 feet distant, a pipe connection was made with Well No. 1, and the gas used as fuel in drilling Well No. 2. The surplus gas was conveyed through a U shaped tube and discharged over a water tank, the water being splashed by the gas over the orifice of the pipe. The pressure of the gas being thus suddenly relieved a ring of ice an inch thick was formed, which remained under the warmest sun. The ice in this case was produced naturally on the same principle that governs the operation of the Kirk freezing machine.

From the time the gas was first struck by the drill up to the latter part of 1876, it seemed to have, according to Mr. Schultz, a constant flow, but as no measurement was made of its pressure it is probable that it gradually diminished.

A little oil being found in Well No. 2, an inch pipe was inserted at the depth of 2000 (the well being 2004 feet deep), and it was proposed to utilize the pressure of the gas to force the oil out of the tubing. The resistance

* Authority, Mr. M. M. Schultz, of Wilcox.

† The elevation of Wilcox being 1509 feet according to railroad levels made subsequent to 1862.

‡ For a complete record of the Well see a paper, by Prof. Lesley, in the Proceedings of the American Philosophical Society, Vol. X., page 238; also one in the Petroleum Monthly of a later date.

1	Number of observations.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Interval.					1.24.30	.15	1.24.45	1.	101		1.25.45	1.35	1.27.20	.45	1.28.05	.10	1.28.15	.30		1.28.45	1.15
2						6.30		7.15				7.15		7.10		7.35		7.35			7.30	
3	Interval.		.55	1.30.55	.05	1.31.	1.	1.32	1.	99	4	1.33.	1.30	1.34.30	1.10	1.35.40	.10	1.35.50	.25	2½	1.36.15	
4		*				7.		7.				6.50		6.55		6.35		6.40			6.55	
5	Interval.	14.05		† 14.05		1.38.	1.	1.39.	.50	87	3	1.39.50	1.40	7.30	.45	1.42.15	.15	1.42.30	.40	2½	1.43.10	.55
6		6.45	.55	1.45.	1.10	7.15	.45	1.46.	.45	87	7	1.46.45	1.30	1.41.30	.05	1.42.35	.40	1.43.	.35	5	1.43.30	1.20
7	Interval.	1.50.50	1.10	1.52.	10	1.45.15	.45	1.46.	1.05	83	6	1.46.45	1.30	1.42.45	.30	1.43.05	.15	1.43.20	1.10	4	1.44.30	
8		6.55		6.50		6.55		6.40				7.		7.		7.		7.			7.15	
9	Interval.	1.57.45	1.05	1.58.50	10	1.52.10	.30	1.52.40	1.05	83	6	1.53.45	1.30	1.49.45	.30	1.50.15	.15	1.50.30	1.05	5	1.51.45	1.
10								6.35				6.55		6.55		6.55		6.55			7.15	
11	Interval.	* 13.50	1.	† 13.45	10	13.35	.30	1.53.15	1.25	99	6	2.00.40	1.35	1.55.40	.50	2.00.05	.15	2.00.20	.50	8	2.01.35	
12		2.11.35		2.12.35		2.05.45		7.				6.40		7.		7.		7.			7.	
13	Interval.	6.45		6.40		7.	.30	2.00.15	1.05	86	4	2.07.20	1.40	2.02.15		2.07.25		2.07.35		2½	2.08.45	
14		2.18.20	.55	2.19.15	05	2.12.45	.30	7.	1.	91	5	2.14.15	1.30	7.	.40	2.15.40	.10	2.15.50	.40	5	2.16.25	
15		6.45		7.05		6.35		6.45				6.45		6.45		6.45		6.45			6.45	
16	Interval.	2.25.05	1.15	2.26.20	05	2.18.20	.40	2.20.	1.	115	6	2.21.	1.30	2.22.30	.40	2.23.10	.10	2.23.20	1.10	5	2.24.30	.35
17						7.05		7.				7.				6.40		6.45			6.45	
18						2.25.20	.35	2.27.	1.	97	6	2.28.				2.29.50		2.30.05			2.31.15	

* The gas did not cease to flow, but rose continuously between the smaller and larger columns.

† The water did not flow in from the pool surrounding the top of the conductor.

offered to the flow of the gas was so great that after a few hours the gas ceased to flow entirely from both wells, Nos. 1 and 2. After 36 hours of inactivity it commenced flowing again with greater energy. In the early part of January, 1877, the pressure of the gas seemed to increase suddenly; but not finding a free passage from Well No. 1, on account of the wooden plug which had been inserted into the casing and which the gas was unable to blow out, the casing was broken at a depth of 175 feet, and the upper portion lifted bodily out of the well. As soon as this occurred the conditions which had existed during the process of drilling were restored, and a column of water was thrown out of the hole every eight minutes to a height of from 80 to 90 feet, and lasting from three to five minutes (M. M. Schultz). This continued until about the middle of May, when the gas from both wells ceased to flow without any obstruction having been knowingly placed in its way.

On the 14th of July, at 1 A. M., the gas made its appearance again and began to throw the water with great energy to a height ranging from 85 to 115 feet; also with a smaller column from three to eight feet high in the intervals between the larger ones; the phenomenon recurring every seven minutes.

During the time that the water columns are thrown out of the well the gas is thoroughly mixed up with the water and is readily ignited. The sight during the flow of the larger column is grand, particularly at night. The water and fire are so promiscuously blended that the two elements seem to be fighting for the mastery.

On July 19th, I closely watched the well for two hours, from 1.19 to 3.22 P. M., and carefully recorded the time of each change in the condition of the water and gas as they spouted from it, noting the number of pulsations in the larger column, and determining its maximum height by triangulation.

On page 129 is a tabulated scheme of the observations from 24 minutes and 30 seconds past one to 28 minutes past two o'clock.*

By an inspection of the intervals between the recurring phenomena, it will be at once seen that there is a marked regularity in the action of the well; in fact, the slight irregularities observed may in a measure be attributed to the personal equation of the observer. In the time included

*NOTES.—1. The time in the table is recorded in hours, minutes and seconds, and the height of the columns in feet.

2. The intervals in the vertical columns show the time in minutes and seconds or seconds alone, during which each phenomenon lasted. The intervals in the horizontal columns show the time in minutes and seconds between the recurrences of the phenomenon.

3. In columns Nos. 4 and 14, where it is stated "the water ceased to run in," it is meant that no water flowed into the hole from the pool surrounding the top of the conductor. It is probable that the water from the water vein at 60 feet depth flows into the well incessantly.

from 10.39 A. M. to 3.15¾ P. M., there were counted 39 of the larger water columns, making the average time between the commencement of each column 6 minutes and 55 seconds.

The accompanying graphical representation will present the action more vividly to the eye. It will be noticed that prior to the water columns No. 3 and 7 no water flowed into the hole from the pool surrounding the conductor. Directly after the larger columns vanish, the water flows into the hole, indicating that all the water is blown out of the well.

Occupying every consecutive 7 ± minutes we have the following sequence of events (See observation No. 9 of the table):

The water from the "water vein" at the depth of 60 feet, and from the pool surrounding the top of the conductor flows into the well for 55 seconds, during which time no gas is detected issuing from the hole. At the end of this time the water from the pool ceases to run in, and the gas rises bubble by bubble for 5 seconds. A column of water and gas now commences rising, makes 6 pulsations, attains a maximum height of 115 feet in 40 seconds, and vanishes in 1 minute. The water from the pool and water vein immediately flows into the well for the second time, continuing for 1 minute and 30 seconds, during which time no gas flows out. At the end of this time the gas rises bubble by bubble for 40 seconds, when the smaller column of water and gas rises, attaining a maximum height of 5 feet in 10 seconds, and vanishes in 1 minute and 10 seconds. The gas still continues to rise but no water flows into the well from the pool for 35 seconds, when the same series of phenomena repeat themselves. Such are the facts.

The explanation of the action may be readily imagined. The pressure of the gas having relieved itself in throwing out of the well the larger column, the water flows into the hole until the pressure of the gas becomes so great again that instead of rising up in small bubbles through the water it rushes out of the well, throwing the water at the same time to a height of from 3 to 8 feet. After the column has vanished the gas continues to rise in great quantities, keeping the water from flowing in from the pool, until the pressure is exhausted. The water now flows into the well till the pressure of the gas in its reservoir has increased to such an extent that it thrusts out of the hole the larger column of water to a height of from 85 to 115 feet.

The smaller column of water is probably produced by the gas coming from the smaller vein at 1200 feet depth, while the larger column is thrown up by the gas coming from the greater vein at a depth of 1600 feet. But, of course, neither the one nor the other column is produced by either of the gas veins exclusively, for the gas must be flowing from both horizons more or less all the time. It will be noticed that more water flows into the hole directly after the larger column has been thrown up, and that the smaller column throws up less water, and *vice versa*.

It was not possible to obtain the pressure or amount of gas coming from the well. The estimated pressure at the time that 175 feet of casing was blown

from the well was about 250 lbs. to the square inch. It is possible that the accumulated pressure at the time that the larger water columns are thrown up may be as high as 250 lbs.; but the constant pressure of the gas if unobstructed by the water would probably not be more than 50 lbs.

The action of the Wilcox well is nothing novel, but the observations are interesting and valuable from the fact that a complete record and history of the well have been preserved, and the accompanying facts add much to what has been recorded of similar wells.

As early as 1833*, Dr. S. P. Hildreth, in a paper on the "Saliferous Rock Formation in the Valley of the Ohio" says: "In many wells, salt water and inflammable gas rise in company with a steady uniform flow. In others, the gas rises at intervals of ten or twelve hours, or perhaps as many days, in vast quantity, and with overwhelming force, throwing the water from the well to the height of fifty to one hundred feet in the air, and again retiring within the bowels of the earth to acquire fresh power for a new effort. This phenomenon is called 'blowing,' and is very troublesome and vexatious to the manufacturer."

A well drilled by Peter Neff, Esq., near Kenyon College, in Knox Co., Ohio, presented similar features to the Wilcox well. At a depth of 600 feet gas was struck which threw out of the well at intervals of one minute, a column of water to a height of 120 feet. "The derrick set over this well has a height of 60 feet. In winter it becomes encased in ice, and forms a huge translucent chimney, through which, at regular intervals of one minute, a mingled current of gas and water rushes to twice its height. By cutting through this chimney at the base and igniting the gas in a paroxysm, it affords a magnificent spectacle—a fountain of water and fire which brilliantly illuminates the ice chimney."

Many of the persons who have visited the Wilcox well during the summer have made a comparison of heights with geysers of the Geyser Basin, and I have been repeatedly referred to for information in regard to the latter.

The following table, compiled from Dr. Hayden's report of the U. S. Geological Survey, 1871, gives some figures of the geysers along the Fire Hole River, in Wyoming Territory.

Name.	Height.	Diameter.	Time.	Observer.
Grand.....	200 feet.	6 feet.	20 minutes.	Dr. Hayden.
Giant.....	140 "	5 "	3 hours.	N. P. Langford.
"	90 to 200 ft.	———	3 hrs. 30 min.	Lieut. Doane (1870)
"	140 feet.	———	1 " 20 "	Dr. Hayden.
Giantess...	250 "	6 to 15 in.	20 minutes.	" "
Beehive ..	219 "	———	18 "	" "

*See American Journal of Science, July, 1833, quoted in Early and Latter History of Petroleum, by J. T. Henry.

NOTE.—Since writing the above it has been reported to me that the gas in well No. 2 has been partly confined, and the increased pressure in well No. 1 has somewhat altered the action of the water and gas. The large column is thrown to a greater height.

Discussion.

Mr. Briggs remarked that the conditions which produce the phenomena of Spouting Wells and of Geysers are sufficiently simple but perhaps not generally comprehended. One of the essentials for the peculiar eruption and periodic discharge which they exhibit, is the enlargement or funnel shape of the upper portion of the cavity; so that at or near the final effort of each pulsation, the confined gas or steam shall be suddenly relieved of a part of the pressure of column or head, and the gas or vapor beneath the liquid, in so large a bubble as to form a chamber or reservoir of gas or steam, be allowed to expand against a less pressure than that under which it had generated or been supplied when lifting the column from the bottom of the well to the place where the well enlarged.

By tracing the phenomenon of a single pulsation, as it may be assumed from the foregoing description to have occurred, it will be seen that, commencing with that period when the gas has exhausted its pressure by a nearly free discharge, after the complete expulsion of the water and relief from any resistance except that proceeding from the depth of water in the shallow pool formed about the mouth of the well (presumed to be from 1 to 2 feet in depth at most), after the pressure of gas falls below this presumed depth, the steps in operation are as follows: A portion of the water in the pool at the top flows back upon the well, quickly forming a column within it and compressing the gas beneath, which is in much too large volume to rise through the water in small bubbles, although some bubbles may force their way up when the return of water first begins and discharge eruptively as they approach the surface, lifting a spatter of water at such discharge, but finally the water column will have acquired such height as to flow quickly down the well and receive such augmentation of quantity as the water bearing strata may supply, filling the well nearly to the bottom, some considerable portion of solid water passing below the level of the upper gas bearing strata and compressing the lower gas by the momentum of the water to the point where its gas supply may be stopped from flowing. Possibly a bubble of gas from the upper gas bearing strata will be formed in the column and be carried downwards, as there is 400 feet of depth of well between these two strata and we can scarcely conceive of 400 feet of solid water, or even 300, to reach between the two levels; but at all events a column of water of some height exists between the upper and lower gas strata when the ultimate recession of water into the well has occurred. The gradual supply of gas from both sources of supply now overcomes and slowly elevates the mass of water, however broken by gas bubbles, giving a nearly uniform pressure of column during such time as it is elevated in

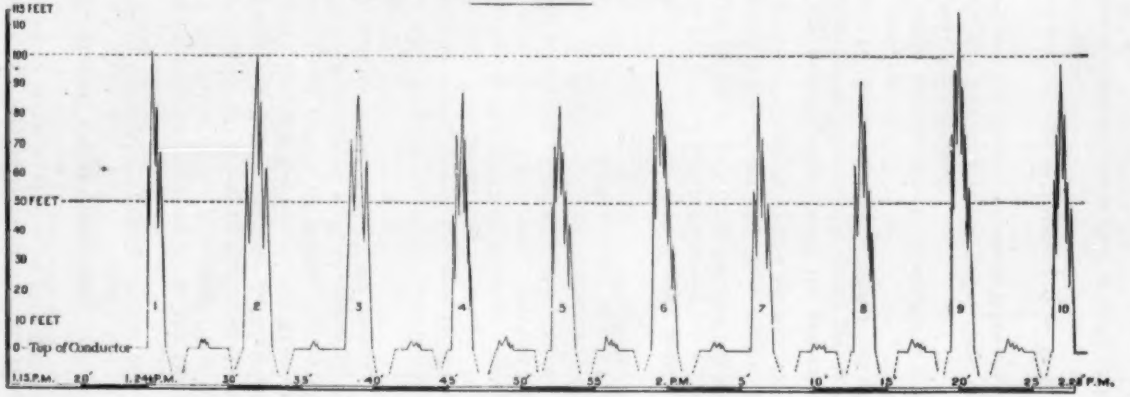
the tube (or well) of uniform section, that is until the column reaches the point where the casing was blown out; there being a great bubble of confined upper as well as a volume of confined lower gas in the bore of the well. Ultimately, before the column reaches the point of enlargement, the volumes of gas become much more considerable than those of the water. It may be assumed, as it is essential to do for the resulting expulsion, that of the 1400 feet (about) of total depth below the top of the casing not over 300 or 400 feet of water column (if so much) ever exists in the well. The water which up to this stage has ascended slowly, now rises into the enlarged mouth caused by the absence of casing, and relieved from pressure of column, as the height reduces, the expanding gas of the upper bubble, becomes eruptive, and the first discharge of 3 or 4 feet height of water is effected. The relief of pressure attendant upon the removal of a portion of the water above into the pool, lifts the lower column of water to above the upper gas bearing strata; but before it reaches the enlargement at the casing the force of expulsion of the upper bubble will have been expended, and the water thus discharged will have returned wholly or in part to the well again, and will have restored the original column and its pressure upon a larger volume of gas with the supply of both gas bearing strata. The regular supply of gas continuing, the column again reaches the point of enlargement, and now, with a great reservoir of gas to expand, the final effort of a pulsation is consummated, with a discharge of gas and water of 85 to 115 feet in height. Allowing for the mixture of gas and water in reducing the gravity of the column, it is possible that the greatest *pulsation of emergence* at the mouth of the well cannot be more than the equivalent to a height of 60 to 90 feet or 30 to 45 pounds per square inch.

In the case of the Geyser the same necessity of conformation of the pit or hole, so far as regards the funnel-shaped mouth to relieve the pressure of water column at or near the top, exists. The heated water is then the reservoir of energy for producing an eruption; a large volume of steam being formed at once when relief of pressure occurs. The phenomena of periodic discharge following a course similar to that described as coming from emission of gas from a strata when the cooled return water comes in contact with the volcanic heated rocks at the bottom of the hole, producing a steam pressure more rapidly than the water circulation will permit the heat to be transferred to the surface of the water quietly and thus lifting the column to the point of enlargement where its pressure is reduced.

Proceedings Amer. Philosoph. Society, Philadelphia, Vol. XVII. page 127. Plate IV. 1877.]

Graphical Representation of the Wilcox Spouting Water-Well, McKean Co. Pa.

The unbroken line on and above the base is the profile of the Water issuing from the Conductor; the Gas rising from the Well at the same time. The broken line below the base indicates the time that no gas is issuing from the Well, and the time that the Water from the Pool around the Conductor is flowing in. The height of the major pulsation in each column was alone determined.



Observations made July 19th 1877, by Chas. A. Ashburner, M.S. Asst. Second Geological Survey of Pa.

C.A.A.

Level Notes and Compass Courses of the Seaboard Oil Pipe Line, from the the Mouth of Black Fox Run, in Clarion County, Pa., to Patapsco River, near Baltimore, Md. Lines run by O. Barrett, Jr., C.E., Western Division; B. F. Warren, C.E., Middle Division; J. B. Haupt, C.E., Eastern Division.

Gen. H. Haupt, Chief Engineer.

(*Read before the American Philosophical Society, October 5th,* 1877.)

The Seabord Pipe Line survey line commences in the Oil Region of Western Pennsylvania, in the Valley of the Alleghany River, at a point one and a-half miles below (south of) Monterey Station on the Alleghany Valley Railroad; takes a nearly straight course over the high lands of Indiana and Cambria Counties; descends the face of the Alleghany Mountain; crosses the mountains and valleys of Middle Pennsylvania; the South Mountain range; the red sandstone plain in front of them, and the hills of Middle Maryland to Baltimore; a total distance of about 228 miles, = 1,202,828 feet.

It passes about fourteen miles south of the county town of Indiana; one mile south of Carrolton in Cambria County; crosses the Pennsylvania Railroad at Elizabeth Furnace; the Broad Top Railroad at McConnellstown; passes through Orbisonia, Shade Gap, Roxboro', Shippensburg, Gettysburg; passes one mile south of Littlestown; two and a-half miles south of Westminster; one mile south of Reisterstown; follows the ridge between Patapsco Falls and Guyron's Falls, and terminates on Curtis' Bay two miles south of Canton, on an inlet of Chesapeake Bay at Baltimore.

Remarks.

In the column marked △ the distance from starting points B M are given in feet, measured on the ground (not horizontally).

The elevation is given in the second column in feet and hundredths.

Note. The decimal point in the 1st, 5th and 7th columns divides the distance into lengths of 100 feet. Thus: 98.35 = 9,835 feet, &c.

The courses given in the second column show the general direction. The line run varies from the general direction in many places, but is seldom more than from one to two hundred yards to right or left of the general course, and in most cases less.

The distances in the fourth column are the distances of a number of shorter courses taken by scale from the plot.

The columns of Maxima and Minima give the undulations, being ordinates at extreme elevations and depressions, or where there are changes in the slope of the ground.

Any further information desired may be obtained from B. F. Warren, 734 N. 20th Street, Philadelphia.

The degrees and minutes of courses begin with 0° at north, running 90° =E; 180°=S; 270°=W, &c.

△	Elev.	Course	Dist.	MAXIMA. △	MAXIMA. Elev.	MINIMA. △	MINIMA. Elev.	
B M	807.45	Elevation of surface of water in Alleghany River at mouth of Black Fox Run.						
0.00	824.20	87½°	9155′	39.30	1143.2	50.90	1110.6	Entrance to McElroy's Coal Mine.
				91.90	1343.6			
98.35	1231.8	118½°	20010′			100.00	1212.0	Creek.
				121.00	1500.1	127.80	1445.9	
				132.45	1496.7	168.00	1210.0	
				170.95	1222.3	178.95	1218.6	
				184.45	1219.1	204.25	1100.0	Catfish Run.
				211.90	1212.8	215.10	1209.7	
				218.15	1212.8	227.50	1185.0	
				235.80	1222.2	242.00	1184.0	
				246.10	1210.0	250.15	1198.6	
				266.15	1252.9	270.50	1235.0	Catfish Run.
				283.80	1290.1	294.70	1271.0	*New Athens.*
				¼ mile to right.				
				314.05	1436.8			
315.70	1420.00	128.25°	39230′			321.50	1280.0	
				331.60	1413.8	337.10	1290.0	Small Run.
				346.90	1419.0	354.75	1359.0	
				360.50	1410.7	368.10	1273.0	
				378.85	1368.6	389.00	1146.0	
				390.90	1182.5	408.15	1049.7	
				418.35	1092.5	439.60	946.0	Turkey Run.
				441.50	984.7	445.30	923.4	ditto.
				450.55	949.3	456.85	848.0	ditto.
						461.00	839.0	Red Bank Creek.
				Line between Clarion and Armstrong Counties.				
				488.00	1219.6	495.20	1083.0	
				504.05	1222.9	509.80	1158.0	
				518.85	1352.3	526.50	1280.0	
				539.40	1384.1	557.00	1055.0	Creek.
				566.65	1375.6	574.00	1198	Run.
				674.55	1525.4	687.40	1356	Creek.
				694.30	1448.0	701.35	1275	
				707.50	1352.0	730.45	997.0	Br. of Mahoning Cr.
731.75	1038.5	126.05°	31030′	736.15	1205.6	740.10	1090.0	Creek.
				762.95	1376.0	784.00	1125.0	Creek.
				811.50	1309.0	824.00	794.5	Mahoning Creek.
				926.75	1450.9	undulating		to
				1011.05	1493.0	1025.40	1276	
				1033.50	1352.0			
1044.60	1290.0	102.45°	16430′	1078.90	1505.6	1085.60	1457.1	
				1098.80	1540.0	1130.50	1371.0	
				1150.90	1550.0	1227.65	1329.0	
1214.10	1401.0	116.10°	18640′	1247.50	1413.0	1260.90	1303.0	
				1266.35	1384.0	1270.75	1257.0	Glade Run.
				1304.30	1350.0	1323.40	1255.0	
				1346.55	1405.0	1359.90	1287.0	Spring Run.
				1377.00	1460	Line of Arm		strong and Indiana Count's
				1387.75	1495	1411.00	1394	
1407.10	1400.0	129.35	42860′	1422.70	1468.0	1460.00	1345	
				1467.00	1372.0	1473.00	1286	Run.
				1486.80	1406.0	1502.30	1257	
				1507.60	1265.0	1511.00	1247	Run.
				1521.30	1503.0	1530.35	1230.0	
				1537.00	1279.0	1540.25	1187.0	Run.
				1547.00	1351 0	1552.80	1365.0	
				1561.30	1469.0	1571.25	1285.0	
				1577.00	1365.0	1586.50	1194.0	
				1599.20	1337.0	1610.40	1224.0	
				1615.25	1247.0	1625.50	1201.0	
				1638.80	1224.0	1663.70	1208.0	
				1682.55	1274.0	1686.00	1214.0	
				1690.40	1332.0	1692.30	1173.0	
				1725.20	1301.0	1735.75	1270.0	
				1745.20	1358.0	1749.70	1238.0	
				1757.20	1331.0	1771.00	1227.0	
				1781.00	1383.0	1785.00	1295.0	

△	Elev.	Course	Dist.	MAXIMA. △	MAXIMA. Elev.	MINIMA. △	MINIMA. Elev.	
				1789.80	1344.0	1794.40	1303.0	
				1802.35	1500.0	1817.75	1259.0	Run.
1842.80	1400.0	121.10′	32090′	1847.30	1415.0	1863.15	1253.0	
				1881.45	1328.0	1885.00	1289.0	
				1898.40	1360.0	1906.55	1328.6	
				1911.20	1336.0	1917.00	1260.0	
				1924.00	1341.0	1931.00	1246.0	
				1950.50	1295.0	1955.00	1277.0	
				1989.65	1484.0	2002.60	1399.0	
				2018.75	1536.0	2030.80	1467.0	
				2057.30	1680.0	2073.75	1505.0	
				2078.15	1621.0	2108.10	1441.0	
				2114.50	1468.0	2126.50	1392	Creek 10′ wide.
				2142.95	1635	2156.10	1425	
				2159.00	1463	2165.35	1384	Two Lick Creek.
2182.90	1480	119.25′	11390′	2206.80	1638	2217.25	1574	
				2228.25	1638	2241.15	1500	Run 4′ wide.
				2253.80	1628	2264.75	1555	
				2272.00	1611	2275.30	1553	
				2281.95	1590	2290.30	1572	Run.
2297.15	1609	160.40′	6540′	2319.80	1671.5	Divide of Two Lick and Mahoning Cr'ks		
2368.50	1433.5	124.10	20690			2372.60	1380	Run.
				2376.15	1440	2407.30	1374	Br. of Two Lick Creek.
				2450.45	1593	2504.80	1527	
				2556.00	1607			
2579.60	1544.7	156.10′	16520′			2521.90	1421	
				2603.30	1557.5	2613.00	1442	Creek.
				2626.15	1625	2640.15	1497	
				2652.95	1666	2661.00	1612	
				2701.05	1962	2710.20	1934	
				2714.60	1959	2732.00	1870	Creek.
				2745.55	1986			
2751.00	1978	129.45′	32020′			2781.65	1831	Run.
				2804.45	1811	2808.50	1786	
				2818.40	1858	2833.55	1807	
				2851.70	1894	2860.00	1868	Creek.
				2882.35	1896	2909.00	1898	
				3019.30	2014	3027.00	1984	Spring.
				3066.95	2096			
3075.80	2055.0	107.40′	13820′			3081.00	2005	
				3143.55	2144	3165.70	2015	
				3171.70	2099	3187.75	2083	
				3200.25	2118	3214.30	2015	
3220.15	2060.9	102.50′	10330′	3233.50	2090	3267.30	2036	
				3277.75	2131			
3324.10	1855	127.30′	6610′			3369.10	1766	Creek.
				nearly level.		3380.00	1757	Same Creek.
						3398.50	1752	Laurel Run.
						3406.00	1751	Chestnut Creek.
				3414.30	1880	3422.00	1754	Run.
				3456.30	1981	3473.40	1814.0	Run.
				3494.00	1917	3500 20	1825	Run.
				3505.60	1876	3514.75	1747	Run.
3515.00	1747.3	88.35′	8480′			3515.75	1744	Same Run.
				3532.40	1765	3524.00	1761	
				3532.45	1999	3550.30	1708	Run.
				level.		3565.75	1687	Creek.
				3581.05	1875	3594.75	1722	Creek.
				3606.65	1877			
3607.90	1859.3	105.30′	12510′			3615.40	1778	
				3630.85	1868	3640.30	1785	Creek.
				3657.15	1868	3669.00	1798	Creek.
						3699.00	1600	Clearfield Creek.
3741.30	1808.5	72.35′	8490′	3765.10	2030	3773.75	1961	
				3796.85	2140	3804.80	2108	
				3824.50	2185			
3820.00	2180	65.30′	7080′	3828.25	2194	3843.30	1910	Laurel Run.
				3862.00	2134	3871.90	2110	
				3888.00	2183	3904.95	1986	Creek.
3906.90	2020.0	62.45′	7805′	uniform rise		3953.10	2256	Creek.

△	Elev.	Course	Dist.	MAXIMA. △	MAXIMA. Elev.	MINIMA. △	MINIMA. Elev.	
3986.00	2408.0	64°30′	7315′	4028.20	2537′	4038.40	2464′	Line bet. Cambria & Blair co
						4039.90	2461	
				4054.95	2596			
4059.60	2564	118°00′	20775′	4064.50	2570	4087.00	2297	
				4092.10	2233	4101.85	1992	Head of Creek.
						4122.15	1722	
				4124.25	1729	4126.30	1663	Creek.
						4133.35	1606	Creek.
				4142.85	1642	4146.50	1627	
				4150.00	1637			
				4154.90	1607	4161.30	1390	
						4181.20	1304	Creek.
						4237.45	1175	Creek.
						4249.00	1154	Creek 15′ wide.
						4256.90	1149	
				4261.10	1175	4272.30	1126	
				4275.00	1138	4282.50	1118	
4287.20	1198	88°00	4605′	4293.80	1248	4297.75	1222	
				4301.25	1246			
				4310.95	1242	4322.90	1067	
4344.00	1044.6		BM.	M. Div.	= 1056.8			Error = 0′.4.

Middle Division.

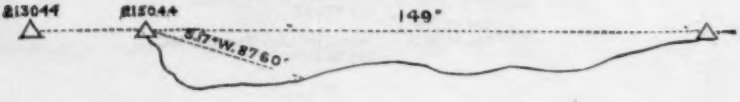
BM. = 1057.2

O.MD	1044.6	110°45′	11450′	31.40	1089′	34.15	1053′	
						37.15	1053	Creek.
				73.63	1102	94.75	1130	Creek.
				100.87	1158	101.60	1154	Creek.
						107.50	1201	Creek.
115.38	1328.6	75°45′	7710′	118.82	1415	124.09	1507	
				137.48	1927	140.19	1974	
				156.48	2412	Sum	mit of	W. Brush Mt.
199.48	1731.5	71°30′	7190′	205.98	1708	219.00	1327	Run.
						240.90	1114	Sinking Valley.
273.93	1104.5	132°35′	4920′	288.04	1107	300.40	1046	
				313.02	1159	316.10	1141	
323.42	1192.79	127°15′	28790′			333.60	1272	Run.
						340.40	1347	Run.
						343.59	1395	
				349.34	1667	362.56	1843	
				374.51	2240	Sum	mit of	E. Brush Mt
						415.76	1168	Canoe Creek.
				456.98	1862	460.84	1835	
				470.02	1907	475.47	1903	
				478.60	1940	Sum	mit of	Canoe Mt.
						485.69	1667	
				496.09	1530	504.76	1249	
				507.13	1229	518.00	1083	Run.
				521.09	1136	537.28	1039	
				550.88	1013	553.00	923	
				504.67	1012	578.14	835	Creek.
				582.10	882			
				587.43	927	590.00	780	Roaring Run.
						601.43	746.6	Juniata River.
619.15	821.4	140°15′	34030′	628.77	886	635.60	740	
				670.60	1340			
				672.70	1364	675.00	1345	
				680.40	1493			
				695.40	1907	Sum	mit of	Tussey Mt.
				715.97	1266	721.38	1259	Creek.
						740.49	1650	
				756.61	2296			
				765.95	2328	Sum	mit of	Tussey Mt.
						780.00	2178	

△	Elev.	Course	Dist.	MAXIMA. △	MAXIMA. Elev.	MINIMA. △	MINIMA. Elev.	
				782.24	2180′	799.35	1787′	
				805.68	1707	825.85	1143	Run.
						844.00	936	Run.
				856.37	897	863.05	813	
				867.79	920	882.24	791	
				888.07	862	892.40	794	
						905.00	772	
				910.20	808	915.60	772	
				921.54	868	925.00	827	
				930.82	872			
961.37	672.6	161.15′	8530′	*		962.75	650	*
See		note	bel'w	975.12	666	1007.46	600	Creek.
						1013.08	630	Creek.
						1031.60	773	
				1035.43	849	1037.53	844	
				1047.14	1137.6	Sum	mit of	Pine Ridge.
1052.28	1072	138.45′	37040′			1067.40	752	
				1074.80	860	1090.38	769	Creek.
				1121.55	903	1126.00	910	
				1132.88	1016	1141.24	912	Run.
				1144.60	1022	1147.70	1013	
				1156.30	1193	1163.04	1050	
				1176.10	1254	1184.00	1019	
				1190.50	1082	1197.90	886	Creek.
				1205.70	1005	1213.20	762	Spring.
				1219.50	819	1256.90	625.3	Raystown Br.
				1285.04	1684	Sum	mit of	Terrace Mt.
						1301.40	1430	
				1304.30	1473	1313.44	1412	
				1320.50	1419	1355.60	1250	Little Trough Creek.
				1368.10	1364	1371.22	1325	
				1391.75	1652	Sum	mit of	Sideling Hill.
				1403.50	1224	1413.37	1100	Creek.
						1425.10	969	Creek.
1429.05	956	140.20′	26375′	1450.92	1242	1461.80	950	Creek.
				1469.20	1054	1474.70	924	
						1481.80	803	Creek in Hares' Valley.
				1495.70	871	1523.36	1269	
				1541.00	1840	Sum	mit of	Jacks Mt.
						1552.50	1653	
				1556.00	1682	1564.70	1631	
				1575.00	1776	1582.80	1582	
				1585.50	1564	1591.80	1513	Creek.
				1611.10	1726	1636.10	1424	
				1637.80	1402	1652.10	1109	
						1657.60	1076	
				1668.70	1083	1679.00	1030	Creek.
1695.74	987	182.30′	11130′	1697.80	964	1784.10	741	Creek.
				1787.54	759			
1815.70	736	155.45′	27700′			1834.70	680	
				1883.10	790	1893.00	670	Gt. Aughwick Cr.
				1930.00	1022	1931.50	960	
				1937.60	1010	1961.20	640	
				1966.00	691	1970.10	708	
				1990.10	692	2006.70	725	Orbisonia.
				2023.70	751	2073.80	726	Rock Hill Gap,
†2130.44	830	149.00′	26690′					
See		note	bel'w			2148.30	835	Creek.

*Note.—From △ 975.12 there appears to be a constant error amounting to 161′ at B.M.; this error should be distributed uniformly—as from tests the variation is constant and uniform.

†From 2150.44 the line follows the general direction of the road through Shade Gap and diverges considerably from a straight line, thus:



△	Elev.	Course	Dist.	MAXIMA. △	MAXIMA. Elev.	MINIMA. △	MINIMA. Elev.	
				2211.50	870′	2244.15	800′	Creek 20′ wide.
				2245.40	903	2255.20	910	Creek.
				2304.70	1094	2322.00	1095	Creek.
				2325.40	1121	2346.70	1097	
				2364.10	1105	2392.60	1111	
						2404.15	1105	Creek.
				2442.90	1150	2454.20	1132	
				2469.10	1167	2475.80	1162	Creek.

If the line be run directly across the mountains on the course 149° it will give the following Maxima and Minima (approximately).

Line across the Mts. from						2150.69	842′	
				2200.00	1770′	2216.20	1325	
				2290.00	1340	2247.00	1020	
				2258.00	1160	2266.50	1070	
				2300.00	1530	2312.00	1380	
						2322.00	1300	
				2328.00	1340	2337.50	1328	
						2342.00	1260	
				2360.00	1500	2377.60	1180	
				2385.00	1220	2475.77	1162	Creek.
2475.77	1162	136°.15′	13230′			2489.40	1249′	
						2503.00	1518	
				2519.10	2060′	2531.20	1601	
						2561.20	1200	Creek.
2618.81	1002	115°.15′	7750′	2645.00	976	2674.20	945	
				2681.00	1002	2694.00	1030	
2697.30	1040	79°.00′	2550′					
2723.20	947	92°.30	8930	2737.70	1023	2751.70	1180	
				2758.20	1224	2764.80		Creek.
				2797.00	2020	Kitta	tinny	Mts.
2826.87	1710	119°.00′	17080′	2864.00	1397	2868.60	1250	
				2876.30	1360	2894.30	1377	
						2916.80	1258	
				2920.80	1272	2942.10	949	Conodogwined Creek.
				2944.00	1030	2952.00	942	ditto.
3028.47	895	120°.55′	22720′	3090.80	844	3108.90	844	
				3111.73	865	3139.00	768	
				3146.50	849	3151.00	810	Creek.
				3164.80	855	3175.40	750	Creek.
				3193.00	824	3229.30	700	Conodogwined Creek.
				3260.80	844			
3266.41	840	125°.00′	21320′	3305.30	780	3348.50	873	[berland Counties,
				3400.00	885	3435.70	849	Line of Franklin and Cum-
				3458.80	835	3464.60		Shippensburg.
				3490.30	821			
3499.28	821			BM. E. Div. = 821. Error 161′.				

Eastern Division.

O BM	659.333	133°.35′	13720′			1140	651′	
				24.00	699′	33.50	671	
				45.70	744	54.00	707	
				63.50	814	79.00	725	
				117.30	773			
				140.00	818			
147.00	856	133°.50′	34830′	188.00	988	207.00	1450	
				211.50	1305	240.00	1130	Creek.
				261.50	1568	278.00	1340	
				348.50	1914	364.50	1861	
				379.50	1953	391.50	1718	Creek.

△	Elev.	Course	Dist.	MAXIMA. △	MAXIMA. Elev.	MINIMA. △	MINIMA. Elev.	
				396.00	1800′	401.00	1718′	
				423.00	1914	427.50	Line	between Cumb. and Adams
						452.00	1425	Creek.
				477.00	1047			
				492.00	1657			
496.50	1635	109°30′	7035′			523.00	1236	Creek.
				531.00	1282	555.50	1113	
567.00	1112	109°30′	6880′	574.30	1102	622.00	825	
636.00	863	138.10	26670			660.00	732	Conewago Creek.
				721.00	812	767.00	705	Creek.
				773.80	766			
				816.50	786	829.00	673	
				838.15	728	877.65	671	
				886.50	643	889.20	666	
				895 25	616			
917.37	630	141.20′	21700′	928.50	654	938.00	613	
				955.00	666	972.20	668	
				987.50	624	1015.00	575	
				1040.70	636	1055.00	525	
						1069.75	495	Creek.
				1077.50	537	1082.35	517	
				1086.50	533	1091.50	496	
				1035.00	514	1103.00	495	
				1108.00	507	1114.60	489	
				1120.00	496	1142.00	461	Strikes Rock Creek.
1145.00	460	175.30′	10950′	Run	ning	along	Rock	Creek.
1256.00		155.30	13920	1281 00	480	1275.00	448	
				1284.00	Leav	es Ro	ck Cr	eek,
				1303.00	472	1313.30	550	
				1330.50	568	1338.00	442	
						1351.00	442	
				1363.00	509	1383.60	414	White Run.
1397.18		126.40′	22300′	1427.50	531	1432.50	508	
				1438 50	528	1443.00	506	
				1447.00	522	1450.00	506	
				1458.00	538	1462.25	528	
				1468.00	535	1472.00	533	
				1479.00	497	1482.50	514	
						1492 40	482	Creek.
				1499.00	524	1533.00	525	Creek.
				1558,00	587	1582,00	510	Creek.
				1606.30	584			
1621.27		136.30′	28680′			1626.80	515	Creek.
				1658 20	524	1679.70	564	
				1691.40	611	1696.70	585	
				1714.97	641	1718.50	632	
				1735.70	604	1746.20	551	
				1758.10	615	1776.20	547	Creek.
				1778,41	596	1788.40	574	
				1829.70	706	1851.93	605	Creek.
				1856.00	Line	bet.	Penn	a. and Maryland.
						1884.70	638	
				1907.70	731			
1926.16	755	137.00′	29140′			1937.70	693	
				1943.50	735			
				1952.70	666	1954.25	618	
						1972.70	582	Creek.
				2013.70	790	2022.70	700	
				2025.70	707	2027.20	686	
				2029.70	724	2041.20	700	
				2048.70	792	2059.70	667	
				2069.00	789	2092.00	603	
				2095.70	716	2110.70	576	Creek.
				2120.70	762	2125.70	720	
				2129.25	746	hol	low	
				2147.70	718	2150.20	683	
				2164.20	698	2166 70	657	
				2171 20	673	2182.45	587	Creek.
						2186.70	593	Creek.
				2189.70	684	2196.70	607	Creek.

△	Elev.	Course	Dist.	MAXIMA. △	MAXIMA. Elev.	MINIMA. △	MINIMA. Elev.	
				2197.25	620′			
2227.70	706.3	137°30′	9775′			2229.50	680′	
				2242.70	725	2252.70	676	Creek.
				2256.70	745			
				2264.70	755	2269.70	726	
				2274.00	742	2281.70	674	
				2288.70	751	2291.70	730	
				2297.70	767	2311.70	678	Creek.
2328.70		188°30′	7150′	2330.20	797	2340.70	739	
				2369.70	880	2382.70	795	
				2396.70	826			
2405.08		152°05′	27870′			2418.70	732	Creek.
				2443.70	861	2452.20	776	
				2471.45	914			
				2481.00	971	2492.20	870	
				2504.70	891			
				2508.45	906			
				2523.70	874	2532.70	819	
				2540.70	843	2543.70	834	
				2563.70	864	2576.20	803	
				2585.35	813	2598.70	814	
						2632.70	738	
				2644.30	780	2652.70	757	
						2662.70	717	
				2676.70	735			
				2696.70	743			
2697.70		152°00′	26340′			2702.20	707	
				2722.70	733	2727.70	650	
				2732.70	685			
				2742.20	649	2745.20	585	
				2747.70	620			
				2752.70	644	2762.70	489	E. Br. Patapsco.
				2785.70	652	2798.20	530	Run.
				2799.70	541	2802.45	461	Deep Run.
				2810.00	520			
				2812.70	534	2820.70	467	
				2831.70	612	2838.70	464	
						2841.70	461	
				2846.70	529	2849.00	501	Creek.
				2855.20	604	2859.70	557	
				2865.70	590	2867.70	544	
				2879.70	572	2885.70	552	
						2886.70	511	
				2888.70	540	2908.00	429	Great Run.
						2916.70	453	
				2923.00	526	2924.70	467	
				2928.20	Line	of Carroll		and Baltimore Counties.
				2929.00	532	2938.10	499	
				2943.70	581	2944.70	508	
				2949.70	519	2951.45	473	
				2954.70	537	2957.70	509	
						2959.70	469	
				2976.30	584			
2981.60	522	190°30′	9460′	3047.10	574	3053.00	475	
						3058.70	474	Creek.
				3068.70	541	3070.70	532	
3077.06		189°45′	9040′	3077.00	606	3078.00	593	
				3085.20	642	3086.70	626	
				3090.70	633			
				3099.30	634	3113.70	556	Creek.
				3123.70	605	3143.45	568	Run.
				3151.00	671			
				3163.30	688	3169.70	626	
				3173.70	639	3187.70	536	
3188.50	533	167°00′	9170′			3191.70	511	Creek.
				3204.10	613			
				3210.70	647	3215.20	625	
				3226.40	683	3237.00	600	
				3241.20	620	3248.20	537	
				3265.70	677	3281.70	677	

△	Elev.	Course	Dist.	MAXIMA. △	MAXIMA. Elev.	MINIMA. △	MINIMA. Elev.	
				3284.70	702′	3288.20	659′	
				3291.20	693			
3297.60		149.15′	12510′			3298.70	616	
				3303.70	651	3309.20	600	
				3320.70	698	3345.70	639	
				3352.70	662	3364.00	645	
				3365.50	650	3368.20	641	
				3371.70	659	3381.70	581	
						3393.30	547	Creek.
				3400.70	591	3401.70	567	
				3403.70	590	3407.00	558	
				3413.20	616	3417.00	579	
3428.70	623	142.45′	18890′			3436.20	533	Creek.
				3454.70	622	3464.70	573	
				3472.70	606			
						3480.20	487	Creek.
				3498.70	577	3505.70	564	
				3508.70	578	3512.70	543	
						3532.60	484	Creek.
				3550.70	591	3561.00	589	
				3574.70	593	3580.70	563	
				3585.10	574	3610.70	500	Creek.
				3616.45	514			
3620.70	490.5	167.45′	10500′			3630.70	483	Creek.
				3636.20	505	3641.70	503	
				3649.20	518	3664.70	508	
				3675.70	579	3689.70	501	
				3690.70	518	3720.70	511	
				3739.80	524			
3743.45		172.30′	12820′			3765.20	494	
				3781.70	525	3805.70	478	
				3815.70	481	3847.20	400	
3874.70	450.6	142.00′	16735′			3880.70	439	
				3883.70	449	3901.20	384	
				3911.20	423	3917.45	393	Creek.
				3980.70	510	3998.45	464	
				4002.20	480	4039.20	326	
						4043.70	337	
				4049.70	398			
4050.20	395	127.30′	13070′			4065.70	317	
				4069.70	326	4076.20	288	
				4079.70	315	4099.70	214	
				4109.10	224	4115.10	165	
				4121.70	173	4136.70	95	Creek.
				4050.70	171	4069.70	98	
				4085.70	159			
4185.00		125.40′	15690′	4090.70	234	4213.70	79	
				4221.35	123	4227.40	96	
				4236.20	140	4241.70	83	
				4250.20	158			
				4264.70	147	4265.70	128	Pond extends to 4275.70.
				4281.70	144	4290.70	89	
				4294.70	119	4302.70	61	
				4310.55	125	4346.70	0	Patapsco R., about 6 miles below Baltimore.

List of Elevations, above Mean Tide, through the County of Indiana, in Pennsylvania, copied from Notes of Survey under Gen. H. Haupt, for the Sea Board Pipe Line.

By O. Barrett, Jr.

(*Read before the American Philosophical Society, October 5th*, 1877.)

Stations.	Elevations.	Trees, &c., Marked with White Paint.
1376.70	1481.9	In Armstrong Co. Land of J. Scott, 1½ m. from Dayton.
1377.00	.....	Line of Armstrong and Indiana Counties.
1378.35	1474.00	6′ right Chestnut Oak. On land of E. D. Sheffer. In woods.
1401.20	1489.55	46′ right Cucumber Tree. Land of J. L. Buterbaugh.
1419.25	1463.35	8′ left White Oak, edge of woods. Land of Sam'l T. Fulton.
1429.15	1470.00	11′ right Apple Tree, in orchard, near dwelling of S. T. Fulton.
1442.90	1461.20	92′ right White Oak, near Public Road. Land of J. A. Wingrone.
1453.40	1433.50	170′ from Pin Oak. Smicksburg 2 miles north.
1481.90	1387.75	80′ right Wild Cherry. Land of Ephraim Ritchey.
1490.75	1403.00	6′ right White Oak, Land of Chris. Good.
1498.90	1305.00	35′ left Poplar. " " " *Smicksburg, about* 2 miles north.
1515.50	1278.10	15′ right spring house of Barnabas Lowe.
1519.00	1313.30	15′ left Apple. Land of Mrs. Lena Lukehart.
1537.00	1292.00	20′ left White Oak "snag." Land of Mrs. Catharine Bowser.
1544.80	1315.95	69′ right White Oak. Land of Mrs. Catharine Bowser.
1558.40	1464.50	90′ left dead tree. Land of John Lewis.
1559.90	1483.50	20′ left fence stake. " "
1561.30	1480.70	52′ right " " " Between two pines, on high hill, very prominent point.
1570.75	1309.30	9′ right fence stake, 150′ right dwelling of John Lewis.
1580.80	1338.50	8′ left fence stake. Land of Isaac Good. About 18 miles to Indiana and 20 miles to Kittanning from station 1580.80
1589.95	1279.30	4′ right dead tree. Land of Isaac Good.
1599.20	1350.10	19′ right dead Wild Cherry. Land of David Elkin.
1604.65	1300.30	37′ left dead tree. " "
1608.90	1246.60	4′ right White Oak. Edge Woods. Land of Jas. M. Wells.
1613.60	1256.50	6′ left Hickory. Edge Woods. Land of Jas. M. Wells.
1631.65	1225.80	107′ left Wild Cherry. Edge Woods. Land of Jas. M. Wells.
1638.30	1237.20	50′ right dead tree.
1642.80	1231.80	16′ left White Oak. Beginning of Woods.
1652.05	1225.45	12′ right " In Woods. Land of Robt. L. Mabon.
1665.50	1219.90	23′ left White Oak. Edge of Woods. Land of J. L. Mabon.

Stations.	Elevations.	Trees, &c., Marked with White Paint.
1669.60	1221.20	138′ left Hickory. Front of Mr. J. L. Mabon's dwelling.
1676.35	1228.45	35′ left White Oak.
1680.65	1279.60	78′ left Red Oak.
1684.20	1276.70	8′ left Maple.
1695.00	1899.30	right of gate post, near Absalom Neff's barn.
1701.45	1216.20	15′ left White Oak. Land of Absalom Neff.
1717.70	1245.90	9′ right White Oak. In Public Road. Land of John Smith.
1725.45	1314.00	28′ right fence stake, between house and barn of Mr. Smith.
1727.55	1313.50	32′ left Ash.
1739.00	1335.70	4′ right Cucumber Tree.
1745.20	1372.90	38′ right Ash. Land of Allen Hamilton.
1757.20	1344.35	73′ left Hickory. Land of Mrs. Hannah F. Hamilton.
1762.85	1303.60	right White Oak. *Smyrna Church* 900′ north.
1776.90	1326.15	15′ left Gum. Land of Silas W. Brady.
1781.50	1395.50	6′ left Pin Oak. In woods. Land of W. A. Hamilton.
1785.95	1321.20	2′ left fence stake. Land of Thomas Stuart.
1794.40	1316.40	21′ left White Oak.
1802.35	1513.60	7′ right Red Oak. Top Hill in woods.
1819.00	1294.40	55′ right large White Oak. Land of James Hopkins. Near Public Road.
1847.30	1428.40	6′ left fence, near dwelling of Moses T. Work.
1868.70	1277.80	15′ right White Oak. In Road. Land of E. I. Work.
1881.45	1341.30	20′ right Pin Oak. In Road. Land of Wm. I. Work.
1889.55	1354.10	70′ left Pine. " "
1898.40	1373.10	4′ right Pin Oak, in woods.
1910.90	1349.00	10′ left White Oak, edge woods. Land of Mr. Steffer.
1926.00	1350.10	8′ left " Land of Mr. Steffer.
1932.15	1271.40	6′ left White Oak. Land of Abner Griffith.
1934.40	1280.90	1′ left fence stake, in Public Road.
1950.50	1318.00	53′ right Locust. Land of Wm. G. Stewart.
1970.90	1347.80	4′ left Chestnut. Land of Samuel Lewis. In woods.
1984.90	1463.90	10′ left Chestnut. Land of J. J. Williams. Edge woods.
1991.70	1493.90	55′ right Chestnut, In field. *Marion*, ¾ mile south.
2002.60	1411.60	5′ right White Oak. In woods. " "
2014.35	1534.40	3′ left fence stake. In field. Land of Levi Spencer.
2018.75	1549.10	5′ left Chestnut. In woods. " "
2028.30	1486.90	14′ left White Oak. In clearing. Land of James Hunter.
2050.00	1666.70	8′ left dead tree in field. Land of James Hunter.
2057.10	1693.70	4′ right White Oak, in Public Road. Land of James Hunter.
2071.20	1627.20	11′ right dead tree. Land of Samuel Lewis. 15 miles to Indiana.
2079.85	1631.70	55′ right Hickory. Land of "Abe" Lowman, Jr.
2088.50	1594.30	3′ left Hickory. Land of Geo. Schrader.
2100.05	1457.80	8′ left Maple in Public Road.
2113.45	1471.50	5′ right dead White Oak. Land of Lorenz Reithmiller.
2118.40	1470.60	9′ right Wagon Shed, near Reithmiller's buildings.
2125.75	1413.00	4′ left dead White Oak.
2140.20	1643.90	3′ left Hickory. Beginning woods.

Stations.	Elevations.	Trees, &c., Marked with White Paint.
2153.50	1458.10	9′ right Lynn, in *new* Road. Land of Solomon Fullmer. In woods.
2155.15	1424.00	15′ right Beech.
2166.25	1398.70	4′ right Beech. In woods. Land of Kinter Heirs.
2167.00	.....	In Public Road.
2167.95	1399.10	1′ right Maple. In woods. Land of Kinter Heirs.
2201.60	1588.10	11′ left Gum. In woods. Land of W. N. Barr.
2206.00	1647.80	1′ left dead tree. Out of woods.
2215.60	1591.00	34′ left Cucumber Tree. On land of Mrs. Eliza Rice. Mrs. Rice's buildings to the right.
2217.25	1587.00	In Public Road. 14 miles to Indiana.
2223.60	1643.80	1′ right small dead Chestnut, Beginning woods.
2233.95	1624.10	8′ right Maple. In woods.
2240.00	1527.80	13′ right White Oak. In woods. Land of Joseph Ober.
2242.35	1515.90	6′ left small White Oak.
2250.90	1620.60	16′ right "Snag."
2256.90	1640.10	7′ left Chestnut. In woods.
2262.00	1628.00	46′ left dead White Oak. Out woods.
2266.75	1586.20	50′ right Stump. Land of Moses and Wm. Lydick.
2278.20	1575.20	4′ left "Big" White Pine.
2284.90	1599.40	9′ left Poplar. Beginning of woods.
2297.15	1621.60	8′ left White Pine, in Public Road on land of Jacob Fyock.
2302.25	.....	In cross roads. Dunkard Church close to the left.
2307.45	1643.90	15′ left White Oak. In Public Road.
2314.90	1665.10	11′ left Gum. " "
2333.75	1653.00	5′ right Chestnut. Land of Geo. Wise. In Public Road.
2338.55	1625.00	10′ left fence post. Solomon Wise's buildings to the right.
2354.00	1556.50	13′ left dead White Oak. Land of Mr. Mumma.
2363.75	1486.20	3′ right White Oak. Mrs. Catharine Barr's dwelling to the right.
2368.50	1446.50	11′ right Pine.
2382.50	1427.70	16′ right Apple Tree. Land of John Buterbaugh.
2393.80	1442.00	4′ right dead Pine. Mills and Dam to the right.
2405.30	1395.00	15′ left dead White Oak.
2417.50	1430.90	14′ left dead White Pine. Land of Mrs. J. H. Stumpf.
2430.35	1535.20	4′ left dead Pine in clearing. Land of Solomon Buterbaugh.
2433.45	1539.70	11′ right White Oak, near Public Road.
2450.45	1606.90	73′ left Pine "Snag."
2457.45	1584.80	56′ left large Maple. Land of Wm. H. Lutman.
2469.35	1581.30	16′ left White Pine. Back of Lutman's buildings.
2480.30	1576.40	4′ left Red Oak. On land of Mrs. McCullagh.
2481.75	.....	In Public Road, near old Planing Mill. Cookport ¼ mile to the south.
2487.30	1578.00	6′ right Chestnut, Land of Richard Cook.
2498.00	1555.30	1′ right Chestnut. In woods.
2515.85	1574.70	2′ right Pine, In Public Road.
2523.10	1559.60	4′ left Pine. " "
2536.50	1549.20	3′ left Pine. " " Land of Geo. Baker.
2553.50	1614.20	11′ right Stump. " "
2559.40	1604.70	16′ right fence " " Land of Peter Leasure.

Stations.	Elevations.	Trees, &c., Marked with White Paint.
2561.75	.....	Peter Leasure's buildings on both sides of road.
2562.85	1580.40	15′ left Balm of Gilead. Public Road.
2572.15	1574.80	12′ right Pine. " "
2584.60	1517.80	6′ right Hemlock. " "
2589.20	.....	Compton's Saw Mill and Dam.
2592.30	1438.80	17′ right small Pine.
2595.45	1486.30	Right Red Oak, in woods.
2603.30	1570.50	4′ left Hemlock, "
2610.10	1512.20	6′ left " " In wood road.
2614.00	1467.90	9′ left " "
2621.95	1619.20	3′ left " "
2626.15	1638.40	20′ left Maple, near Public Road. Spruce P. O., ½ mile north. Cherry Tree 5½ miles north. Indiana 16½ miles south-west.
2628.25	1626.70	4′ right Hemlock. In woods.
2638.30	1527.00	3′ right White Oak. "
2640.15	1510.00	Two Lick Creek at Repine's old Saw Mill.
2642.95	1528.70	9′ right Maple. Land of J. C. Repine.
2655.15	1680.10	8′ right Stump. Land of Thomas Patterson.
2661.00	.....	Public Road. Church to left.
2664.50	.....	Patterson's buildings to left.
2666.34	1671.40	4′ right Chestnut.
2676.20	1736.20	7′ right Chestnut. Land of J. C. Leasure.
2683.45	1869.10	28′ left Chestnut. In road and in woods.
2691.50	1920.30	1′ right Chestnut Oak. In woods. Land of Thomas McDowell.
2701.05	1974.80	9′ left Chestnut Oak Land of Robert Pershing.
2705.20	1956.70	28′ right fence post.
2707.50	.....	Pershing's buildings close to left.
2710.20	1946.60	4′ left fence stake.
2714.60	1972.20	5′ right Chestnut Oak.
2719.55	1963.30	1′ left fence stake in Public Road.
2722.90	1940.60	20′ right Hickory. Land of J T. Thomas, Sr.
2729.00	1906.00	17′ right Chestnut. Land of O. J. Williams.
2739.65	1965.30	5′ right Chestnut Oak. Land of David Martin.
2745.55	1999.20	8′ left Stump. *High point*. Divide between Alleghany and Susquehanna waters.
2751.00	1991.40	19′ right Stump.
2752.00	.....	D. Martin's buildings to right.
2762.25	1970.80	6′ right Stump. In Public Road. Martin's store to right. 18 miles to Indiana. 16 miles to Ebensburg.
2770.80	1941.90	30′ right dead Pine. Land of J. Martin.
2774.25	1905.70	8′ right Hickory. Land of Mrs. Nancy Keith.
2779.70	1848.30	2′ left Beech. Beginning of woods.
2781.65	1843.90	4′ left Beech. Land of J. Martin. In woods. On waters of Dutch Run, flowing into the Black Lick.
2786.55	1830.20	4′ right Pine. *About* the line between Indiana and Cambria Counties.
2790.65	1825.30	4′ left Hemlock.

The whole of the stations are not given, as I thought it not necessary.

The stations "run" by hundreds of feet and the decimals of a hundred feet.—Station 2790.65 would read: two hundred and seventy-nine thousand and sixty-five feet; or, 52.85 miles.

Obituary Notice of JOHN C. CRESSON.

BY FREDERICK FRALEY.

(*Read before the American Philosophical Society, October* 19, 1877.)

John Chapman Cresson, late Senior Vice-President of the American Philosophical Society, was born in the City of Philadelphia, on the 16th day of March, A. D. 1806. He was the eldest son of Joseph Cresson and Mercy Chapman.

His paternal ancestor was Solomon Cresson, who came from France to America in the latter part of the 17th century. On the mother's side, he was descended from John Chapman, who came to Pennsylvania in 1684, among the first settlers of the Province, and who was one of the principal Surveyors for William Penn. On both sides the family were distinguished members of the Society of Friends, his grandfather, James Cresson, being an esteemed Minister. His grandfather, Dr. John Chapman, was a man of very eminent ability, by profession a Physician, and filled many public stations with honor and fidelity. He was a member of the State Legislature, and also of the House of Representatives of the United States. He was a member of the American Philosophical Society, having been elected February 12, 1768.

After receiving the usual elementary education in

the primary schools, the subject of our notice was placed as a pupil in the Friend's Academy, then under the charge of Thomas Dugdale and Joseph Roberts. These were two of the best instructors of their day, and under their care he secured a thorough classical and mathematical education. He was very early distinguished by the accuracy, extent and diversity of his knowledge, and the training which he received under these eminent men in careful habits of study, and in becoming thoroughly acquainted with what he intended to learn, characterized the whole of his life and gave a remarkable tone to everything he did.

After receiving such an education, his first impulse was to study medicine, and he made the usual prelimi nary preparations for it that prevailed in those days, and for some months seemed to consider it as his future profession. But while he delighted in the study of its principles, he shrank from the labors and uncertainties of the practice of it, and after very valuable acquisitions in that noble science, he abandoned the study and determined to become an Agriculturist. He, however, cherished an ardent love for medicine, and the members of that profession, who were so fortunate as to enjoy his friendship in after life, have often spoken in high terms of the accuracy and extent of his medical knowledge.

About the time of making this change in his plans for a profession, he became acquainted with the late Wm. H. Keating, who had been recently elected Professor

of Chemistry applied to Agriculture and the useful Arts, in a Department of the University of Pennsylvania, established by the Trustees, to meet what was then a matter of great necessity, and the results of which as we shall see hereafter were very important to the City of Philadelphia. In his attendance upon the lectures and other instruction of Professor Keating, he added greatly to his stock of knowledge, and he was therefore well fitted to begin the study of Agriculture.

He was placed under the charge of the late Isaac Price, of Chester County, and spent over a year in his family and under his instruction, becoming well grounded in all of the details of farming, and doing with his own hands every kind of farm labor. He subsequently entered the family of the late James Worth, of Bucks County, as pupil and friend, and with him completed his education as an Agriculturist. Shortly after attaining his majority, a farm in Cheltenham Township, Montgomery County, was purchased for him by his father, and he prepared to enter on the real business of life. In May, 1827, he married Miss Letitia L. Massey, daughter of Charles Massey, with whom he lived happily for almost fifty years. The issue of this marriage was one son and two daughters; the daughters died in early childhood. The son, Dr. Charles M. Cresson, is still living, and is an esteemed and useful member of our Society. Thus settled on his farm, and ardently attached to Agricultural pursuits, he went to work manfully to make his business a suc-

cess. But in those days farming was far from profitable; produce of all kinds bore low prices, and with all his zeal and industry, and leading his hands in all work, the results gave no profit to represent even a moderate interest on the cost of the farm. After fighting fortune in this way for several years but without immediately abandoning his farm, he entered into partnership with two of his cousins and engaged with them in commercial business. The farm was sold in 1834 and he removed to Philadelphia, and from this time his real and useful history begins.

He became a member of the Franklin Institute in 1831, and there met a host of ardent men, the founders and builders up of that noble Institution. Prominent among these were Samuel V. Merrick, William H. Keating, Robert M. Patterson, Alexander Dallas Bache, Isaiah Lukens, Benjamin Reeves, Matthias W. Baldwin, Franklin Peale, George Washington Smith, John Wiegand, John F. Frazer, and others equally worthy, with whom he immediately became intimate in his friendship, and bound by a kinship of labor in the attainment and application of useful knowledge. Here he was in a congenial field, his old friend and preceptor, Keating, was in the forefront of the zealous workers of the Institute, and Mr. Cresson soon showed that while engaged actively in farming he had not neglected the text books of Philosophy and Science.

His knowledge of mechanics and chemistry was very comprehensive, and was immediately made available

by placing him on committees charged with the investigation of mechanical and scientific subjects. We have not space to particularize all such labors, but when we say that for more than forty years he was an active member of the Institute, always ready for duty and always earnest in work, some estimate may be formed of this part of his career.

While thus, as it were, entering the threshold of his practical life, the corporate authorities of the City of Philadelphia, in 1835, determined to erect the Gas Works for the supply of the city. This work was carried out by Samuel V. Merrick, Esq., as Engineer, who had prepared himself for it by a visit to Europe, and a personal inspection of the Gas works in operation there. On the completion of the first section of the works and putting them in operation in 1836, Mr. Merrick desired to be relieved from the superintendence and care of the manufacture of Gas, and he was accordingly relieved. It then became an important question for the Trustees of the Works to decide as to whom the management of so important a business should be entrusted. After a patient inquiry and a scrutiny of the claims of other gentlemen, the place of Superintendent was tendered to Mr. Cresson, and being strongly urged by his friends Merrick, Keating, and Bache, to accept it, he yielded to their wishes. Mr. Merrick soon afterwards resigned as Engineer, and Mr. Cresson was then elected to that place as well as the one before held. He occupied these important and highly responsible

positions for twenty-eight years, and the complete success of the Works in their manifold constructions, manufacturing processes, and the safety and extent of the distribution attest his marvelous skill and ingenuity. In the manufacturing department he was eminently successful, and the profits as well as the usefulness of the Works have become proverbial. While engrossed in such labors the Professorship of Mechanics and Natural Philosophy became vacant in the Franklin Institute, and in 1837, Mr. Cresson was unanimously chosen by the Managers to fill it. He accepted the appointment, and in this new field he soon took a high rank among the scientists of the day. His lectures were remarkable in the comprehensive clearness and simplicity of their style, and for the fullness and completeness of their illustrations, and his old students speak of them to this day in the highest terms of praise.

While he was holding this chair, the Controllers of the Public schools of Philadelphia determined to reorganize the City High School, and placed that work in the hands of Professor Alexander Dallas Bache. The plan adopted by him embraced a department of Mechanics and Natural Philosophy, and upon his recommendation Mr Cresson was elected to the Professorship. He held this office for about two years, discharging its duties with great fidelity and success, but the time taken was found to trench too much on his other engagements, and he resigned it; to the great regret of his associated professors and the students.

Mr. Cresson had by this time won a distinguished reputation in the scientific world, and in appreciation of it, the Trustees of the University of Pennsylvania conferred on him the honorary degree of Master of Arts.

A year or two later, he received from the University of Lewisburg, Pa., the honorary degree of Doctor of Philosophy.

In the year 1855, Samuel V. Merrick, Esq., the chief founder and second President of the Franklin Institute, resigned, and Mr. Cresson was elected almost by acclamation, to succeed him.

The establishment of the Franklin Institute in the year 1824, chiefly through the devotion and personal exertions of Messrs. Merrick and Keating, led to a more thorough appreciation of the dependence of the useful arts on the physical sciences. The Institute was soon a pronounced success. It brought together the best scientists of the City, and the great body of intelligent manufacturers, mechanicians, merchants, and professional men, and it thus entered on a career of usefulness which probably has not been excelled anywhere.

On coming to the City, Mr. Cresson entered actively in the work of this body and for upwards of forty years was an active participant in its labors and usefulness. As a member or chairman of important committees, as President, Professor and Counselor, he was always prepared and earnest. His usefulness was manifested

in an eminent degree as Chairman of the Committee on Science, to which place he was elected on the resignation of Professor Bache, in 1844, and the reports and records of that Committee illustrate in their vast fields of inquiry, and the valuable results to inventors, the fertility of his own resources and the wisdom of his selection of the sub-committees charged with the duty of making investigations.

As a philanthropist, Mr. Cresson was equally distinguished. He was for many years a Manager and one of the Vice-Presidents of the Pennsylvania Institution for the Instruction of the Blind, one of the Managers of the Episcopal Hospital, and of the Western Saving Fund Society, and a member of, and contributor to, other charitable institutions. But his services in these respects were specially made available for the Institution for the Blind, for the Saving Fund Society, and for the Episcopal Hospital, his connection with them terminating only at his death, and the management of these great charities expressed their sorrow for his loss, in resolutions that truly declared his merits and services.

In the year 1852, he was elected a Trustee of the University of Pennsylvania, which office he also held at the time of his decease.

In this body he was distinguished, as in all other places, by devotion to the best interests of the institution, heartily co-operating and sometimes leading in the great improvements that have been made in the

methods and extent of the instruction given to the students.

Mr. Cresson served for several years as a Manager of the Schuylkill Navigation Company, while its affairs were under the Presidencies of Solomon W. Roberts, Esq., and Charles Ellet, Jr., Esq., and he gave useful aid in preparing plans and carrying out the great enlargements of the canals and other works of that Company during the years 1845 and 1846.

He was elected President of the Mine Hill and Schuylkill Haven Railroad Company, in the year 1847, which office he held until his death. Under his administration of the affairs of this Company, its trackage and equipments were largely increased, and it became the principal carrier to the canal and railroad trunk lines of the Anthracite Coal trade of Schuylkill and Northumberland Counties.

He was appointed one of the original Commissioners of Fairmount Park, and was a prominent participant in perfecting the organization of that body, and in adopting its preliminary plans for the extension and arrangement of the Park. Having at this time been relieved from some of his other appointments and duties, he found in the work of the Park a renewal of his old affection for rural occupation, and he cheerfully yielded to the call of the Park Commission to become their Chief Engineer. He entered on this field of duty with a zeal and fidelity that soon manifested his power and genius.

His plans for the improvement of the Park were simple but comprehensive. He seized upon the natural features of the land and the presence of its ancient forest trees to lay out roads and pathways, that should traverse attractive and beautiful spaces and present to the eyes of the visitors resting places of a graceful and attractive character.

To him the arrangement and embellishment of the Park was a labor of love, and he still worked for it when unable to leave his house and bed, while suffering from acute disease.

He had the wide area of the Park mapped, as it were, upon his brain, and his directions to his assistants for the prosecution of their work were as clearly given as if he were standing by them in the field. But he yielded at last to the necessity of parting from a work calling for such continual mental labor, and he resigned at the close of the year 1875.

In the year 1839, he was elected a member of the American Philosophical Society, and the proceedings contain many evidences of his success as an original investigator and careful student of science.

He was elected one of its Vice-Presidents in 1857, and by continued re-elections he became the Senior Vice-President, and held that office when death terminated his membership with us.

He visited Europe once on professional business, and twice for medical advice, and during these visits became acquainted with the prominent scientists of

Great Britain and France, and he often spoke of the heartiness with which he had been received by them, and of the special benefits he had derived from his intercourse with them.

We have now briefly sketched the active life and labors of Mr. Cresson, and the results which they brought to him in the way of reputation and honors.

It remains to us now to endeavor to portray him as a man, and to show that with the endowment he had of such goodly gifts, he was equally blest with moral and social virtues, and with physical strength and beauty.

Mr. Cresson had a stature of over six feet in height, his frame was in harmony with it in being large and well-proportioned. His head, although not large, was admirably formed, and his countenance was mild and beautiful, lighted up with eyes brilliant and expressive.

His manners were easy and dignified, receiving every one with affability, kindness and courtesy, but never permitting undue familiarity. He possessed great conversational powers, and his extensive reading and knowledge gave him the command of a vast variety of subjects, which enabled him to become an acceptable associate of old and young, learned or unlearned, and to give exquisite pleasure to all brought into personal contact with him.

He always had strong religious convictions, and his early training, as a born member of the Society of Friends, undoubtedly gave him his robust morality.

He lost his membership in that Society by his marriage with a lady who was not a member, and while he always remained on terms of great intimacy and friendship with his old friends of the good Quaker faith, his mind was awakened to religious principles of a more definite and outwardly expressed form, and he became by baptism and confirmation a full member of the Episcopal Church. In this membership, as in everything else he did, he was ardent, consistent and useful, freely giving of his labor and substance in aid of Church-work, and by personal example giving force and beauty to his Christian life. In his family he was the affectionate and dearly loved son and brother, the kind, indulgent and devoted husband and father, entwined around every heart with the strongest bonds.

He was a man of great moral and physical courage, never fearing to call a fault or a crime by its right name, and never hesitating by personal interposition to endeavor to check or subdue a wrong doer whom he found engaged in work threatening the peace or security of private citizens or of the public. Sustained by these well-balanced virtues, and by his sincere religious principles, and his thorough trust in the goodness and wisdom of God, he went through a life of nearly seventy years, always cheerful, happy and useful, and looking forward to the close with faith and hope quite equal to those of the patriarchs of old.

In his early manhood he had two very severe attacks of illness, both of which brought him to the verge

of the grave, but even then his meek and quiet spirit and his strong trust greatly aided his physicians, and he seemed to be providentially raised for his future work. During the holding of the great Sanitary Fair in Philadelphia, in the year 1864, in the preparation for which and in its management and success, he had borne a great share, the first symptoms of the disease which terminated his life made their appearance.

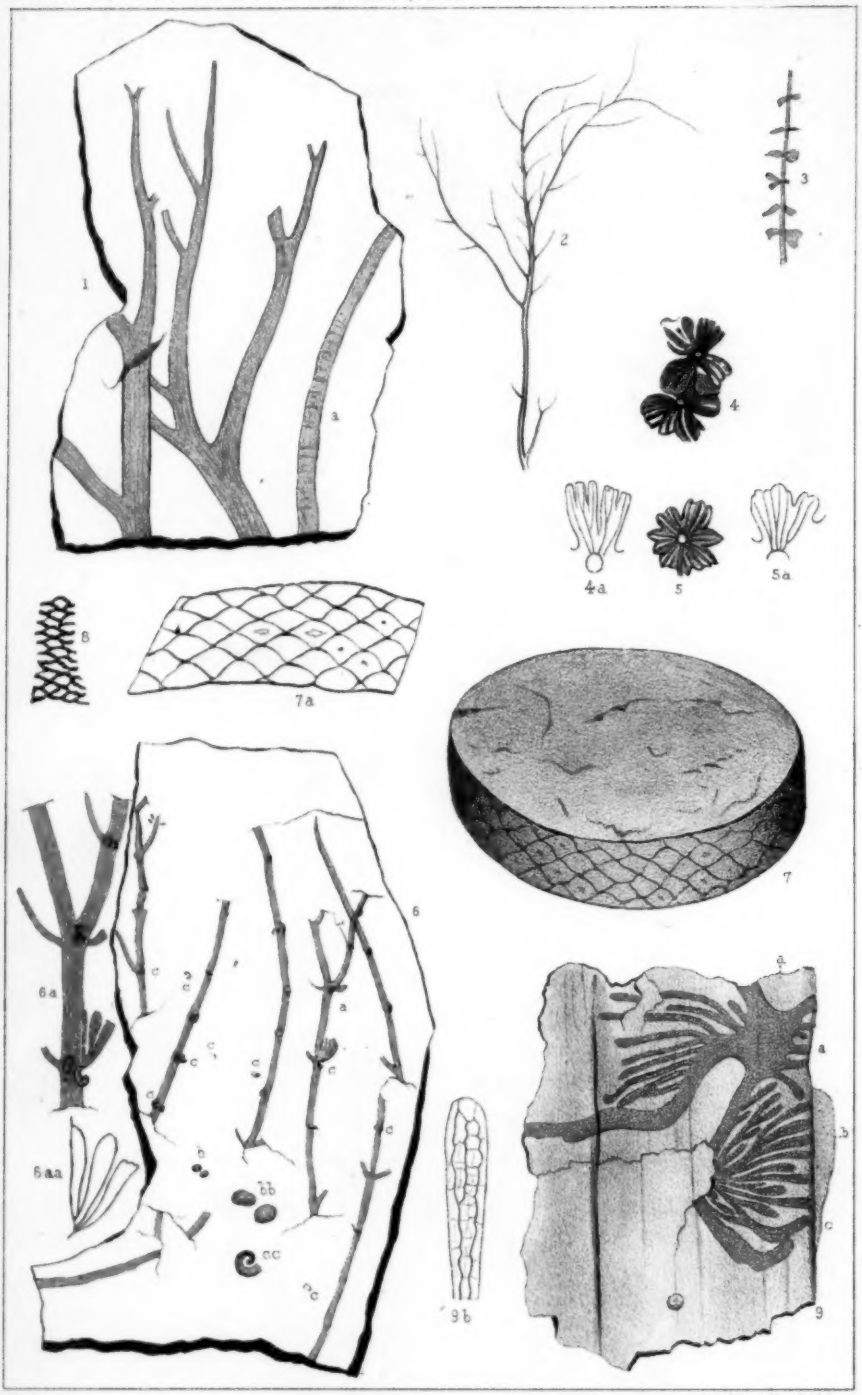
He, however, speedily recovered from the violence of the first attack, but the disease assumed a chronic form, and went on, year by year, in spite of usual remedies, increasing in its activity, and gradually leading to that prostration which, in 1872, took him to Europe to seek special advice. He returned much invigorated by the treatment and voyage, but in a few months the unfavorable and violent symptoms again returned, and he made a second visit. On this occasion he submitted to several operations of lithotrity, and embarked for home in the hope that he was permanently relieved. He, however, had a painful voyage, and after he reached home he gradually became more and more impaired in health, and was finally confined to his chamber and couch. Here for many months he suffered the most intense pain, which could only be made bearable by the strongest opiates, but in the short intervals of ease he was the same cheerful and ready friend, pouring out the vast stores of his knowledge, philosophizing on the pleasures of nature, the mysteries of life and death, and looking forward with hope,

patience and faith, to the time when all pain and suffering would cease, and his reward for it all would be found in the peace and rest of Heaven. It was during these years of trial and suffering that all the beauties and harmonies of his character shone with marvelous effect. His friends left his chamber greatly wondering what manner of man he was who could bear so much without repining, and they went forth thankful for such an example, and greatly strengthened by it for their own application.

He sank quietly to rest as the sun was setting, on the 27th day of January, 1876, in the 70th year of his age, taking his departure with his eyes resting on the old forest trees of the Woodlands, then stript of foliage and taking their winter rest, but with the consciousness on his part that the coming Spring would awaken them to a resurrection of beauty, and that he also in due time would rise again in a spiritual body, and be made one with his Master, Christ, in glory.

For more than sixty years he was my associate friend and brother. His life was part of my life, we lived and labored together in the same fields, partook of the same cares and trials, and while I pay this loving tribute to his memory I feel that I but speak for all when I say

"None knew him but to love him,
None named him but to praise."



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Silurian Land Plants. Fig. 9. 9 b. Carboniferous fungus.

Land Plants, recently discovered in the Silurian Rocks of the United States.

By Leo Lesquereux.

(*Read before the American Philosophical Society, October* 19, 1877.)

The first remains of land plants known from the lower Silurian, were found some years ago by Dr. S. S. Scoville in blue, hard, sandy clay, or marly shale, of the Cincinnati group, on Longstreet Creek, six miles east of Lebanon, Ohio.

This discovery, an important one for the Natural History of this country, was recorded in the Am. Journ. of Sciences and Arts, Jan. 1874, p. 31, and the remains, representing two fragments of stems or branches, were briefly described at the same time. Their reference to the botanical group of the *Sigillariæ*, was then hypothetically admitted, from the likeness of the scars of the surface of one of the fragments to species of this genus: *S. Brardei*, *S. Menardi*, etc.

Later, Prof. Newberry, to whom the same specimens were communicated also, gave an acconnt of them with figures in the same Journal, Aug. 1874, p. 110, considering them, in the conclusion of his remarks, as casts of some large *Fucoids* or marine plants. As the doubt could not be cleared up by mere discussion, the subject was dropped, in the hope that the discovery of other materials of the same kind might afford more light upon the true character of these vegetable remains.

In the meanwhile, as the specimens of Dr. Scoville had been returned to me, I made a new and more attentive study of them, had them carefully figured, and the characters given in the original description being recognized as exact, all the documents, specimens and drawings were, at the request of Prof. J. D. Dana, sent to him for examination, and also referred by himself to Profs. D. C. Eaton and A. E. Verrill of New Haven. These celebrated Naturalists, the more competent judges on the subject, recognized the fragments as positively referable to land plants by their characters.

Other specimens still more evidently representative remains of land vegetation were soon after communicated from the Silurian of Cincinnati, and also from the lower Helderberg Sandstone of Michigan; and as still more of the same kind had been promised, the publication of the descriptions was postponed, in order to have, for indisputable evidence, a sufficient number of these vegetable fragments, from which also the relative characters of this new flora might be discerned.

Just now a branch of a fern has been obtained from the Silurian Schists or Slates of Angers, France, and the fact is reported to the Academy of Science of Paris, by Count Saporta, with the remark, that this important discovery was forestalled in America, where remains of Silurian Land Plants had been found whose description would be greatly desirable at the present time.

We have thus a sufficient reason for the publication of the following documents relative to the subject.

Description of Species.

Genus PSILOPHYTUM, Daws.

Quat. Journ. of the Geol. Soc. of London, p. 478.

"Lycopodiaceous plants, branching dichotomously and covered with interrupted ridges or closely appressed minute leaves; the stems, springing from a rhizome, having circular areoles sending forth cylindrical rootlets. Internal structure, an axis of scalariform vessels, surrounded by a cylinder of parenchymatose cells and by an outer cortical cylinder of elongated woody cells (prosenchyma). Fructification probably in lateral masses protected by leafy bracts."

The species which I have to describe here differs by these points only from the generic description: the stems of one of them has not any interrupted ridges or striæ of any kind; both are without leaves. But in the species described by the author the leaves are either rudimentary or, more generally, the stems are naked, either in their original growth or by denudation, caused by maceration or other physical circumstances. For example, *Psilophytum elegans* and *P. glabrum* have no leaves; *P. robustius*, judging from figure 121 in Dawson's *Precarboniferous plants* of the Geological Survey of Canada, bears leaves at the extremity of the branches only, and the stems appear smooth as they are also in *P. glabrum*.

Psilophytum gracillimum, sp. nov.

Pl. I, fig. 2.

Stem very slender, dichotomously branching, smooth or naked half round, slightly channeled in the length; branches numerous, of various length, filiform.

The stem is scarcely one millimeter thick at the base; the upper branches, curved as from a spiral unfolding, are slender, gradually attenuated and capilliform, or of the thickness of thin thread at their extremities.

The plant embedded in hardened, blue, shaly clay or marl, is transformed into coal, part of the branches broken and displaced having left their prints as half cylindrical concave moulds. This character, as also the depression in the middle and along the whole axis, proves the woody or vascular texture of the plants and of course separates them from the *Fucoids*.

Comparing this specimen with species published by Prof. Dawson from the Devonian measures of Canada, its relation to *P. elegans*, Quat. Journ. Geol. Soc., Nov. 1862, p. 315 Pl. xiv, fig 29, 30, is recognized as quite close. But the affinity of the characters is still more marked with a plant of *Psilophytum* as restored in its original state for exemplification of the genus in the Proceedings of the same Journal, Jan. 1859, p. 479, fig. i. If this figure, whose stem is without leaves, was the exact representative of a peculiar species I should have considered our silurian form as identical with that of Canada.

The specimen from Cincinnati, a piece of shale, one or two centimeters thick, has on the reverse fragmentary remains of the same plant, especially some upper branchlets like fig. 2*a*, more evidently hooked than those of the main stem. Both the upper and lower surface of the shale are smooth, have no animal remains; but the intermediate layers hold small molluscan species characteristic of the Cincinnati Group.

Habitat. Near Covington, opposite Cincinnati, in the bed of the Licking River. Found by Mr. Ed. Ulrich; communicated by Rev. H. Herzer.

PSILOPHYTUM CORNUTUM, sp. nov.

Pl. I, fig. 1.

Stem thick, dichotomous; divisions variable in distance, the terminal ones short, pointed, nearly equal in size and length; surface slightly rugose and irregularly striate.

The branches in the lower part are thick comparatively to their length, three to four millimetres, irregularly striate when decorticated, or merely punctate upon the thin bark, with small projecting dots resembling the basilar remains of scales or small decayed leaves; lateral branches short, narrowed to a sharp point; the upper or terminal ones about equal in length, appearing like a pair of small pointed horns.

The species is comparable only to some of the fragments not specified but figured by Prof. J. W. Dawson (Geol. Survey of Canada, Fossil Plants of the Devonian and Upper Silurian formations, figs. 243, 244). The author remarks, "that these fragments are probably originating in the Upper Silurian of Gaspé; that as they are found in the lower part of the Limestone which underlies the Devonian Gaspé Sandstone and become more abundant in the upper beds, this suffices to indicate the existence of neighboring land, probably composed of the Silurian rocks, and supporting vegetation."

From the preservation of its branches even to the smallest subdivisions, the specimens here represent part of a plant embedded in the place of its growth. The matrice is a piece of very hard calcareous shale, seven to eight millimetres thick, bearing on one side irregular undulations like ripple marks, without any trace of organic remains, and on the other the fragments of plants as figured here. The branch in *a* represents a different species, and indeed a marine or rather a brackish plant, closely related to species of the present genus *Chorda*, Stack. This fragment seems to have been mixed in the tide pools with freshwater or land plants growing there. For, another thick specimen of the same locality, and compound, bears a profusion of marine mollusks, and has only branches of this as yet undescribed marine species: *Calamophycus septus*, whose character may as well be here fixed.*

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* Genus CALAMOPHYCUS.

Same characters as the species.

CALAMOPHYCUS SEPTUS, sp. nov.

Fronds simple, cylindrical, elongated, gradually tapering to a point;

Habitat. Lower Heldeberg Sandstone, Michigan. Discovered and communicated by Dr. Carl Rominger, State Geologist.

CALAMARIÆ.

ANNULARIA? Brgt.

Stem articulate; leaves virticillate, lingulate, gradually narrowing to the base, either pointed or rounded at the top; midrib thick.

Our species differs from the generic characters by the absence of a midrib. The leaves, however, are very small, indistinct, their substance being amalgamated into that of the stone, and the nervation is nearly obsolete.

This vegetable form might be referable to *Sphenophyllum*, or even to some peculiar generic division. Its characters relate it positively to the sections of the Calamariæ, as far as it is fixed until now.

ANNULARIA ROMINGERI, sp. nov.

Pl. I, fig. 6.

Stems long and slender, articulate, smooth; articulations at regular short distances, inflated, bearing oblique branches and leaves; leaves small, lingulate, apparently flat, either truncate or rounded at the top; nervation obsolete.

The inflated nodi and the flattened leaves, refer the plants to *Sphenophyllum*, while the obtuse, entire, numerous leaflets, disjointed to the base, relate it to *Annularia*. From both these genera it is removed by the smooth, not ribbed, nor striate stem, and by the oblique direction of the branches. By this last character it is allied to *Asterophyllites*. The articulations are numerous, five to eight millimeters distant; the leaves scarcely three millimeters long. The direction of the branches, all in the same way and nearly parallel, shows that they were attached as branches to the same stem, and not displaced by water or by any kind of transportation. Like the fragments of fig. 1, they have been embedded at their place of original growth. This fact is rendered still more evident by the presence of small Serpulids (fig. 6*c*, enlarged *cc*), a considerable number of which are attached to the stems and strewed over the stone.

The specimen bears also (fig. 6*b*,) oval granulate protophytes: *Xanthidia?* seen enlarged in *bb*.

Habitat. Same as the former species in the lower Helderberg sandstone formations of Michigan. The compounds of the specimens are still harder and more calcareous. Found like the former, and communicated by Dr. Carl Rominger.

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cavity divided by transverse membranes, either passing through the whole diameter, or connected in the middle to vertical subdivisions.

The internal parieties, irregular in distance and thickness, are distinctly seen through the smooth epidermis, which, moreover, is often destroyed, the internal structure being thus clearly exposed. The cavity of the stem is inhabited by the same species of *Serpulid* as seen in fig. 6 *c*.

SPHENOPHYLLUM, Brgt.

Stem articulate, leaves verticillate, cuneiform, crenulate, dentate, or lobed at the upper part which is truncate or rounded; midrib none; nerves straight, diverging fan like, simple at the base, dichotomously forking once or twice.

Here also, the vegetable fragments, which we refer, legitimately it seems, to this genus, differ in one point from the typical characters established from Carboniferous specimens. In these, the leaflet, generally four to six, are separated to the very base or free. In the Silurian plants, the whorls or leaflets, four or five, compose a single leaf, the divisions being lobes, cut indeed to near the point of attachment to the stem, where they are joined in obtuse sinuses. The character is distinctly seen upon the specimen fig. 4 and 5, enlarged in 4[a] and 5[a]. None of the authors describing this genus, since it was fixed by Brongniart, has remarked upon the connection of the leaflets at their base, though this connection is often represented by the figures given of species of *Sphenophyllum*, as for example, *S. oblongifolium*, Germ. and Kaulf. in Geinitz, Verst. v. Sachsen, pl. xx, fig. 12, where a whorl is represented with six leaflets free from the stem, whose place is marked by a circular round central scar, the leaflets being united at their base as by a ring. I must say also, that in the very numerous specimens of *Sphenophyllum* which I have had for examination, I have very often remarked this connection of the leaflets, but never, however, as distinct and as distant from the base as in the following species. In *S. Schlotheimii* and *S. oblongifolium*, the nerves are positively simple at the base, though two or more in the same leaflet. This character of course implies a connection of the border of the leaflets at or near the base, and in this case, they do not leave distinct impressions of their point of attachment to the stems. I therefore admit the Silurian plants as truly referable to this genus, the difference remarked in its characters being merely specific and apparently proper to a type not yet fully developed.

SPHENOPHYLLUM PRIMÆVUM, Lesqx.

Pl. I, figs. 3–5.

Stems or branches slender, articulations close, equidistant; leaves in whorls of four or five leaflets connected towards the base and joined by slightly obtuse sinuses; leaflets either truncate and crenulate at the top, or sometimes deeply split or lobate; nerves simple at the base, sparingly dichotomous, forking mostly once, even simple.

If we would not take into account the connection of the leaflets, the relation of this species to *S. Schlotheimii*, Brgt., and especially to *S. oblongifolium*, Germ., as figured by Geinitz (loc. cit.), would appear very close. The difference would be marked merely by the shorter leaflets or the smaller size of the plant and the less enlarged divisions. In the Carbon iferous species, which is also frequently found in the American coal meas ures, the veins, simple at the base, and generally two for each leaflet, have also few divisions, forking only once or twice.

The specimen of fig. 3, have the stems distinct, slightly striate, even slightly inflated at the articulations, a character observable only with a strong glass. Fig. 4 has also the stem distinctly seen between the two whorls, and even fig. 5 has, dimly seen, a remnant of stem as represented upon the figure.

There is a difference in the size and the subdivision of the leaflets of fig. 3; but the woody matter of the plants softened by decomposition has penetrated the clay where the vegetable fragments are imbedded and the outlines of the leaflets are indistinct. On one of them only the nerves are perceivable. The identity of the species represented by fig. 3, with those of figs. 4 and 5, is not ascertainable, but they all evidently represent the same Genus.

There is in the Museum of Comparative Zoölogy of Cambridge a piece of true *granite* bearing remains of a fine branch of *Sphenophyllum;* three whorls of leaves, whose stem is destroyed by decomposition, but whose outline and nervation are perfectly and very distinctly preserved. The positions of the whorls is half quincuncial, two of them placed at the base and one between them at a distance above; the centres of the leaflets representing the three points of an equilateral triangle.

The leaves doubly larger than those of our fig. 5, measuring two centimeters in diameter, are divided into five lobes, distinct to a distance from the round central point of attachment to the stem; truncate and crenate at the top; with each three to five nerves; simple at the base and forking only once in the middle or near the point. The divisions of the border are irregular as in our figure, which it represents exactly in just double size.

We have been more than once discussing with Prof. Agassiz the origin of this remarkable vegetable fragment. Now that congeners are recognized in the Lower Silurian its presence upon granite is explainable, perhaps, as resulting from the casual deposit of a branch of *Sphenophyllum* thrown out into a basin of fresh water, upon granite rocks bordering swamps. Or possibly, the plant grown in place has been preserved by the drying and hardening of a film of decomposed vegetable matter, which seem to adhere to the surface of the granite, As the vegetation of the carboniferous is known by remains of materials heaped in place for a long period of time, and preserved into the compounds formed by deposits of the same age, the mode of preservation of this plant upon granite, is therefore different. Hence the reference to the Silurian of this branch of *Sphenophyllum* is merely authorized by the identity of its character with those of the species described from the Cincinnati group.

Habitat. Covington, opposite Cincinnati, specimen fig. 3, discovered by M. E. I. Ulrich. The fragments communicated by Rev. H. Herzer are in fine grained blue clay or marl, a compound like that where *Psilophitum gracillimum* is embedded. Specimen fig. 4 was sent by Mr. Mickleborough, School Principal, and found by him in the corporate limits of Cincinnati, in a locality known as Limekiln Run, about three hundred and seventy feet above low water of the river. That of fig.

5 was communicated by Mr. C. B. Dyer. It is upon the surface of a stone exposed for a long time to atmospheric influence. All the specimens are from around Cincinnati, in connection with invertebrate animal fossils of the Cincinnati Group.

Plants of the same kind have been found many times already it seems; for Professor Mickleborough informs me that another specimen discovered within the clay, somewhat obscure, and apparently like the one of our fig. 3, was washed and rubbed in order to expose the leaflets more distinctly, and in that way the leaves were nearly totally effaced. Another offered for sale was from description like that of fig. 5. Still others have been mentioned to me. They have been considered by some collectors as the work of insects; by others as fucoidal or coralline productions, like *Oldhamia;* and by others as specimens of the vegetation of the Carboniferous transported by drift. All these suppositions are contradicted by the fragments found imbedded in the clay or attached to pieces of hardened clay of the same compound as the Cincinnati blue marl, and still more by the described characters of these plants.

Protostigma, Lesqx.

This Generic name is provisionally admitted for the description of fragments of stems whose relation to species of *Sigillaria* and other types of vegetables of the Devonian and the Carboniferous is surmised from the rhomboidal form of the scars or bolsters marked upon their bark. This form is very commonly seen upon plants of this kind. It characterizes in its multiple more or less definite transformations, the impressions of the outlines of the points of attachments of simple leaves to stems, branches or trunks of trees of the old formations. Therefore, it would not be surprising to find it already traced upon Silurian woody stems or branches. The reference of those original marks, as long as they are not defined by the vascular scars in the middle, is not possible This is implied by the name under which the remains are described.

Protostigma sigillarioides, sp. nov.

Pl. I. fig. 7–8.

Branches or stems cylindrical, scarcely flattened by compression; surface marked by rhomboidal cicatrices, enlarged on the sides, contiguous and in spiral order, with indistinct impressions of oval vascular scars in the middle.

I refer to this specific form three specimens, two of which are figured here. The fragment of branch, fig. 7, is represented in its natural size. It is slightly obliquely compressed, and thus, the lateral bolsters are somewhat disfigured on the two sides, and displaced from their normal position. But on the face as seen in fig. 7 and 7 a, the scars are preserved in their original arrangement. Even the central vascular points are distinctly seen in the middle of some of the bolsters, though the whole impression is of course somewhat obliterated by erosion of the mould, or by decomposition

of the vegetable fragments embedded into the clay. Another specimen not figured is larger, seven centimeters in diameter, nine centimeters long, nearly exactly cylindrical, with irregular more or less distinct ribs, marked crosswise by large wrinkles or irregular protuberances, which do not show any distinct relation of form and position between them. Therefore, both these fragments are identified merely by their cylindrical shape, representing stems or branches, and by their common habitat. The compound of both is exactly of the same matter, a hard bluish clay or marl mixed with grains of coarse sand. This compound has taken the place of the woody matter destroyed by maceration, and therefore nothing is left of the original vegetable fragment but the outline of the stems and the impression of the scars of the bark.

The fact of the total disappearance of woody fibres in fossil specimens cannot afford an argument against their reference to land plants; for even in the coal measures, trunks of *Sigillaria*, *Lepidodendron*, etc., are very often recognized in sandstone merely by cylindrical outlines of the trunks, and impressions of the scars of the surface of the bark. This mode of petrification is general for isolated fragments of wood.

As related to the same kind of vegetable we have a fragment, fig. 8, found near Cincinnati, in strata of the Cincinnati group, and which confirms the reference of the specimens discovered by Dr. Scoville both to the locality named, Longstreet Creek, and also to the formation of the Cincinnati group. This specimen at the same time represents more evidently the *Sigillarioid* character by its rhomboidal form, the cicatrices and their position in spiral being still more distinctly seen than in fig. 7, though the piece of bark whose impression is so well preserved has been apparently flattened by compression. No trace of vascular scars is remarked however. These scars are generally erased in specimens whose surface bark has been decomposed and destroyed.

As remarked above, cicatrices of the same character, often without central points, are seen on the surface of the bark of *Artisia*, *Leptophleum rhombicum*, *Sigillaria Brardii*, *S. Defrancii*, and other species of the coal.

I have a remarkably fine branch of an *Ulodendron* from the Cannel coal of Pennsylvania, which bears outside cicatrices exactly like those of fig. 7, with oval central vascular scars. The size of this branch is about the same, for it measures twenty centimeters in length, and is only twenty two millimeters broad, though slightly flattened. Its impression into cannel coal is perfectly distinct. Hence the objection against the reference of the specimens of the Silurian to land plant on account of their small size is groundless.

On the reign of organized beings to which these fragments are referable there can be therefore no doubt, for considering merely the size of the stems and their cylindrical form they evidently represent plants.

The question is therefore on the relation of the stems to land or marine plants. Besides the authorities which have been quoted as regarding as evident the relation of these fossil remains to land plants, the analogy of

the characters described and their comparison to those of some vegetable of the coal is evidence of their nature. And though these remains have been found in old formations, wherefrom as yet no trace of land plants had been obtained, the doubt on that score is now removed by the discovery of other plants of the same kind in the Lower Silurian of North America, and still more by that of a Fern in the Lower Silurian of France, the schists of Angers, which seem to be related by synchronism to the Cincinnati Group.*

On the character of this American formation, T. A. Miller remarks, in his Catalogue of American Paleozoic fossils, "that in the Western States of North America, where the Utica Slate is absent from the Hudson River Group, the upper part of the Lower Silurian is generally called the Cincinnati Group. Its strata exposed in Ohio, Indiana and Kentucky, do not exceed one thousand feet in thickness. The lower part is probably the equivalent of the upper part of the Trenton Group. The remainder belongs to the Hudson River Group. The total thickness of its exposure scarcely exceeds one thousand feet.

Some of its characteristic fossils as *Bellerophon bilobatus, Strophomena alternata, Zygospira modesta, Leptena sericea, Buthotrephis gracilis, Beyrichia chambersi, Calymene senaria, Isotelus gigas* and *I. megistos*, pass entirely through the Group. *Trinucleus concentricus, Triarthrus becki, Orthis multisecta, O. emacerata, Streptorhynchus hallia, Ambonychia bellistriata, Modiolopsis cincinnatiensis, Cycloconcha mediocardinalis, Lichenocrinus crateriformus,* and *Chetetes (?) jamesi*, are confined to the lower half of the group. *Glyptocrinus decadactylus, G. dyeri, G. nealli, G. fornshelli, Lichenocrinus tuberculatus, Streptorhynchus filitexta, S. subtenta, S. sulcata, S. sinuata, S. nutans, Orthis insculpta, O. subquadrata, Rhynchonella capax, R. dentata, Cypricardites haynesi, Anomalodonta gigantea, A. alata, Anodontopsis milleri, Favistella stellata, Tetradium fibratum,* and *Streptelasma corniculum*, are found only in the upper part of the group. Some fossils occupy only a few feet in vertical range, as *Orthis insculpta, Orthis retrorsa, O. emacerata, Glyptocrinus nealli*, and *Streptorhynchus sulcata.*

This formation is composed in its whole of alternate layers of blue marl and limestone of variable thickness, the limestone layers rarely attaining one foot.

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* Since the preparation of this paper, I have received from Rev. H. Hertzer, 15th Oct., 1877, three small specimens distinctly related to the fragments described above by the characters and disposition of the cicatrices of the surface, but greatly different by the form of the bodies. One of them is comparable to our figure 8. It is a little larger, convex on the surface, and seems part of a branch. The two others, both of the same size, resemble gibbous tubercles, or rather small door knobs, four to five centimeters in diameter, with border rounded and the upper surface flat or slightly convex. One of them has in the middle a scar-like depression re-

The schists of *Calymene Tristani*, where the fern mentioned above was recently discovered, have been considered by Dufrenoy as an upper member of the Caradoc sandstone of Great Britain. The Cincinnati Group is generally referred to this formation. Its relation, however, to the schists of Angers is not positively fixed. The preponderance of species of *Calymene* like *C. senaria;* of analogous Genera, *Triarthrus becki*, etc., so common in the blue shale of the Cincinnati epoch, seem to indicate a close relation between both formations of Europe and of America. The enumeration of fossils considered characteristic of the Cincinnati group may afford by comparison more positive evidence of the geological relation of the strata where the first Silurian remains of land plants have been found.

It is a remarkable fact that the character of these Silurian plants, described above, give us like a microcosmical representation of the flora of the Carboniferous, so simple and at the same time so admirable in the multiple subdivisions of its specific forms. The coal flora is a compound mostly of vascular cryptogamous plants: Lycopodiacæ, Ferns and Equisetaceæ, and of some Phænogamous Gymnosperms whose types are apparently related to the Cycadeæ or to the conifers.

We now have represented in the Silurian,

1st. The *Lycopodiaceæ*, by species of *Psilophitum;* diminutive forms but primitive types of the *Lepidodendræ*, represented in the coal by very large trees distributed in a number of generic and specific divisions.

2d. The Ferns, by a species related to *Paleopteris* or to the group of the *Neuropteridæ* which makes the finest and most common species of the coal. The fern of the schists of Angers is named *Eopteris Andegavensis* by Saporta, who discovered it.

3d. The *Calamariæ*, by *Sphenophyllum* and *Annularia;* these forming two sections related to the *Equisetaceæ*, but whose vegetable affinity is not satisfactorily ascertained. They represent Cryptogamous acrogens like the ferns.

6th. The *Sigillariæ*, placed by some authors as an order of plants between the Conifers and the Cycadeæ, or representatives of the Phænogamous gymnosperm. We have, it seems, a species of this group in the *Protostigma*.

The *Cordaites* now are considered Conifers.

From the preponderance of large fossil trunks of Conifers in the Devo-

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sembling the point of attachment of a tuft of leaves. Both are marked around on the borders and upon the top surface by rhomboidal cicatrices in spiral order like those of our figure 7. Some of these especially along the border are deep and have very distinct central mammillæ like points of vascular scars. These organized bodies are attached to broken pieces of Silurian limestone, bearing upon the lower part fragments of small marine mollusks. This, together with their shape, their convex or flattened surface, seems to prevent their reference to *Sigillarioid* plants. They look however like miniature trunks of *Cycadeæ*, which for many of their species

nian one may expect to find remains of the Pine family in older formations. When therefore we get from the Silurians fragments of leaves of *Cordaites* (a probable discovery, for they have been found abundant in the Devonian) we shall have all the essential types of the plants of the Carboniferous flora already represented in the oldest paleozoic times.

A Species of Fungus recently discovered in the shales of the Darlington Coal Bed (Lower Productive Coal Measures, Alleghany River Series) at Cannelton, in Beaver County, Pennsylvania.

By Leo Lesquereux.

(*Read before the American Philosophical Society, October* 19, 1877.)

The discovery of a *Fungus* in connection with plants of the coal measures is not less remarkable than that of land plants in the Silurian.

Lindley and Hutton, in their Fossil Flora of England, 1831-33, have represented (plate 65 of the first volume) a kidney shaped, round, flattened body, whose outline and surface, marked by zones of alternate density and coloring along the borders, recall somewhat the characters of some of the hard *Fungi* seen upon old trunks of the forests at the present time and known as *Polypores, Bolets*, etc., or generally called *Sponge-Mushrooms*. The characters of this fossil organism are so uncertain that the authors themselves, though applying to it the Generic name of *Polyporites*, consider as very doubtful its reference to the vegetable kingdom.

Mr. Bowman, the discoverer to whom the species is dedicated as *P. Bowmanni*, remarks, that one of his specimens might be taken for the scale of a fish or of some great Saurian. Since that time no kind of remains referable to *Fungi* has been seen in the coal, except one specimen found in the Anthracite measures near Pottsville, Pa. It is apparently identical with the English species and does not afford any more light upon its nature. This specimen, however, contradicts by its habitat its reference to the animal kingdom, as no remains of this kind are found in the Anthracite measures of Pennsylvania.

But there are in the Tertiary Lignitic of the Rocky Mountains some clay beds associated with coal, wherein are intercallated shaly fragments, colored

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have, at our epoch, globular or button-like stems impressed with cicatrices of leaves, and sometimes flattened and depressed at the top toward the central axis, where the tuft of leaves is coming out. If, therefore, such analogy could be admitted, these specimens would confirm the opinion advanced in considering the probable reference of the branches inscribed above. But this suggestion is too hazardous in its application to remains found in connection with Silurian limestone. For after all, these remarkable fragments may altogether represent one of those organisms like *Uphantænia, Dictyophytum*, etc., whose nature seems to partake of the character of land and marine vegetables, and whose relation is still unknown.

in concentric zones by penetration of iron in such a way that they exactly represent the appearance of the fossils described by the English authors. The zones, about two millimeters wide, are of different hardness, and the soft white ones being more easily disintegrated, they form a series of alternately elevated and depressed concentric bands, similar to those described as characters of the *Polyporites* of the coal.

However this may be, we have now from the Carboniferous a fossil plant which is by all its characters positively referable to the *Fungi*. This plant which was discovered under the bark of a *Sigillaria* is referable to the Genus *Rhizomorpha*, a fungose substance which even until the present time has very rarely been recognized with organs of fructification, and is therefore admitted as a kind of *mycelium* or as the first stage of the life of a *fungus*. Species of various and numerous forms of these vegetable organs are commonly found under the bark of trees or between layers of decaying wood in the forests, and some have been described under different specific names.

RHIZOMORPHA SIGILLARIÆ, sp. nov.

Pl. I, fig. 9.

Stem flattened irregular in form, round, polygonal, elongated and linear or amorphous; branches diverging all around, either simple or forking, even anastomosing in various directions, inflated towards the top, club shaped and obtuse or slightly flattened by compression, and marked upon the surface by a netting of narrow wrinkles resembling veins and their divisions in veinlets.

The figure exactly represents the specimen which botanists will easily recognize as bearing the appearance of some of our present so-called species of *Rhizomorpha*. The surface wrinkles, distinctly seen in fig. 9 b enlarged, seem to have been produced by compression and contact of an upper layer of bark reposing upon them. In their normal state the same appearance is remarked upon living forms of these *Fungi*. It is the same with the flattened body, the mode of branching, the different size and length of the branches, which are evidently widened and modified in their form and directions according to the space left under the bark for their development.

Though no doubt could be entertained about the relation of this organism, which was discovered in detaching the upper layer of bark of a *Sigillaria*, I nevertheless referred the matter to the opinion of some of my corresponding friends, to whom I sent the figure of the plant in order to have every possible evidence on this subject. Among others Dr. Casimir Roumeguére of Toulouse, France, who has large collections of *Fungi* and who is known by numerous scientific memoirs on this difficult branch of botany, answered my request by the communication of many specimens of the different forms of *Rhizomorpha* of our time whose characters are comparable to those of the fossil one. Remarking on its relation as far as it could be recognized from the figure of this organism (the same as that reproduced here) he says: I was extremely interested by the examination of your *Rhizomorpha Sigillariæ* and startled by the appearance of structure which seems to relate that American fossil organism to European con-

geners ; I have especially examined, in comparison, the described forms of *Rhizomorpha subcorticalis*, where I find characters which have removed my first hesitation in regard to your views. One of these forms, the *teredo* of Persoon, has few ramifications, nerves anastomosing, and the primary branches are flattened, enlarged and rugose as in the fossil specimen from Cannelton. The form *latissima* described by Kick, in the flora of Flanders from under the bark of *Betula alba*, has a flattened body resulting from the impression or cohesion of some stems, etc.

From the specimens communicated to me, most of the forms of *R. subcorticalis* present the mode of anatomosis in abnormal direction, as seen at the base of the branch c. Others have a flattened stem when unfolding under some closely pressed piece of bark ; but the branches generally take their cylindrical form when they come to more space especially where air is accessible. Though it is always difficult to find the top of the branches they are generally inflated or club-shaped as in the fossil specimen.

Dr. Roumeguére adds to the dry specimen a figure of *R. subcorticalis*, which represents a stem flattened and enlarged, as is the body of our fossil, with branches bearing at the surface small tubercles composing a false *peridium*, one of which, more advanced into maturity, has produced a club shaped body identically similar to those of *Hilaria digitata*, an autonome *Fungus*. This production has been as yet very rarely observed. Except that the ramifications of the branches of that living species are longer and not inflated at the top, which is not discernible in the specimen, the fossil form is remarkably similar to it.

I received also from Professor C. H. Peek, of Albany, some specimens of *Rhizomorpha* more or less representing the character of *R. Sigillariæ*.

No fossil plant published until now from any of the geological formations of Europe or of America has any relation to this. In Sternberg, Vers., *Aphlebia tenuiloba*, represented in Vol. II, pl. lviii, fig. 2, might be quoted as bearing some relations to the plant of Cannelton by its branches irregularly diverging from an enlarged amorphous central nucleus. But though this species, a mere variation of *A. adnascens*, Pr., represents a parasite plant, it has, like the others described under this generic name, a distinct system of nervation, according to which, the divisions of the primary stems are in an outside or upward direction, and therefore do not, and cannot anatomose either in right angle or in abnormal direction, as is the case with plants of cellular tissue. Thus we would have only for comparison, outside of the *Fungi*, marine plants or Fucoids, and of course the presence of marine plants in connection with *Sigillaria*, even under the bark of trees of this kind, is an impossibility.

Habitat. I found this vegetable organism in shaly cannel or cannel shale of the Cannelton coal, of Beaver County, in company with the proprietor, Mr. I. F. Mansfield, who in pursuing systematic researches for fossil remains has obtained a remarkably rich series of rare and new species of plants of the Carboniferous. The character of a rib of Sigillaria is easily recognized upon the figure of the specimen, which bears also one round scar of the under surface. The upper layer of bark transformed into coal was broken in small fragments to fully expose the fossil *Fungus*.

On some new or little known Reptiles and Fishes of the Cretaceous No. 3, of Kansas.

By E. D. Cope.

(*Read before the American Philosophical Society, August* 17, 1877.)

TOXOCHELYS LATIREMIS Cope.

Final Report U. S. Geol. Surv. Terrs. II. pp. 98, 299.

Two nearly complete crania of this species found by Mr. Sternberg, enable me to give the genus a definite position in the system.

The prefrontals have an extensive mutual contact, and extend to the external nares, where they are somewhat contracted by the superior processes of the maxillary. They descend to the vomer, and are extensively in contact with it. There are no distinct nasal bones. Lachrymal foramen rather small. The temporal fossa is extensively roofed, and the supraoccipital crest much produced backwards.

The posterior nares are rather anterior, and are separated, and not underroofed by the osseous vomer. This element expands in front of the nares, where it separates the maxillaries.

A foramen separates the maxillaries from the palatines, and the ectopterygoids expand laterally. The superior alveolar surface is wide, and slightly concave. The external border is elevated and acute, and the inner border is slightly prominent and is roughened.

The characters above adduced show that the genus *Toxochelys* is one of the *Cryptodira*, and that it is distinct from *Euclastes* (Cope) of the cretaceous No. 5. In that genus the posterior nares are underrun by a production of the vomer, and the alveolar faces of both jaws are much wider. The general form of the skull of *Toxochelys* is much like that of many *Trionychidæ*, but from these the characters of the marginal bones of the carapace, and the form of the extremities separate it.

ICHTHYODECTES GOODEANUS sp. nov.

This largest species of the genus is represented by a right premaxillary and a large part of the maxillary bones. The alveolar border is concave at the anterior part of the latter, and then becomes convex. The maxillary border is incurved at its anterior extremity, so that the line of teeth is turned inwards as well as strongly upwards, the middle part of the border being the most prominent. In this respect it differs from the other species, where the anterior part of the alveolar border is the most prominent. The anterior border is sigmoidally curved, and the vertical diameter is twice the transverse. The premaxillary teeth number thirteen and are somewhat compressed so as to have opposed cutting edges; they are without grooves or ridges. The maxillary teeth are round in section. The posterior maxillary condyle is not protuberant, and is decurved anteriorly. The maxillary underlaps the premaxillary to near its anterior border.

Measurements.	M.
Depth of maxillary behind condyle	.047
" " at "	.053
" premaxillary	.069
Length " at middle	.037
Four functional maxillaries in	.020

This species is dedicated to my friend Prof. G. Brown Goode, of Middleton, Conn., collaborator of the Smithsonian Institution.

I may here state that another very distinct species of this genus is the *Ichthyodectes arcuatus* (*Portheus accuatus* Cope. 4to Report U. S. Geol. Surv. Terrs. II. p. 204). It is characterized by the attenuation of the bones of the face, and jaws, and the small size and large number of its teeth. Those of the maxillary bone are so small as to become obsolete on the posterior half in old individuals.

ICHTHYODECTES ACANTHICUS sp. nov.

The smallest species of the genus, distinguished by the attenuated and curved crowns of the teeth. It is represented in my collection by portions of the dentary, parasphenoid, and other bones. The teeth on the anterior part of the dentary bone are nearly round in section, and their enamel is smooth. The crowns are curved inwards towards the apices, which are slender and acute. The anterior tooth is on the extremity of the dentary. The lateral processes of the parasphenoid are wide and flat, and are pierced at the base by the usual two foramina. The interorbital portion of the bone is concave in the section of its inferior surface.

Measurements.	M.
Length of the crown of a tooth	.005
Diameter " " "	.001
Five mandibular teeth in	.012
Width of parasphenoid at middle	.006
Depth of parasphenoid at middle	.004

This species and the last described were obtained by my assistant, Chas. H. Sternberg, from the chalk of the Cretaceous No. 3 of Kansas.

ORICARDINUS TORTUS gen. et sp. nov.

Char. gen. Teeth inserted in shallow aveoli, with the roots more or less exposed; on the posterior half of the maxillary bone unequally so, so as to be pleurodont. The anterior part of the maxillary bone depressed, with superior articular facet, and united with the premaxillary by a ginglymus.

This genus is apparently nearly allied to *Pachyrhizodus* as I have defined it. In that genus the anterior maxillary teeth are strongly pleurodont, and the maxillo-premaxillary suture is squamosal. To *Oricardinus* must probably be referred the *P. sheareri* m.

Char. specif. This is derived from a right maxillary bone and a num-

ber of vertebræ, supposed to belong to the same individual by my assistant, Russell Hill, who discovered it.

The proximal extremity of the maxillary bone is depressed, both the external and internal aspects presenting prominent ribs. The inner rib soon disappears, and the alveolar border becomes interior in position, the teeth then assuming a more pleurodont character. The external rib continues, and rises so as to form the superior border of the jaw, but continues to have an oblique direction outwards. It is separated by a longitudinal concavity from the portion that bears the alveoli. The teeth are subcylindric in section, and the crowns are acute and incurved. The proximal end of the maxillary forms a condyle for transverse movement, which is divided by a transverse groove. Above this groove the extremity is fissured.

The vertebral centra are somewhat hour-glass shaped, and present a deep longitudinal fossa on each side of the base of each neural and hæmal arch, which is divided by a vertical rod on partition of bone, which strengthens the arch. The arrangement is that seen in the genus *Empo*, The sides of the centra are marked with rather regular linear grooves, which disappear at the contraction.

Measurements.		M.
Length of maxillary bone preserved		.066
Distal depth		.011
" width		.005
Proximal depth		.005
" width		.006
Eight teeth in		.020
Diameter of caudal centrum	longitudinal	.010
	transverse	.009
	vertical	.010
Diameter of anterior centrum	longitudinal	.009
	transverse	.011
	vertical	.009

In the *O. shearerii* the dental alveoli are transverse to the long axis of the maxillary bone, while here they are longitudinal or round; the bone is more laminiform in the *O. tortus*.

ANOGMIUS FAVIROSTRIS sp. nov.

The characters of the genus *Anogmius* Cope having up to the present time rested upon but one species (*A. aratus*), it is satisfactory to be able to confirm them by the study of new material. This, which was obtained in Kansas by Mr. Sternberg, consists of the almost entire superior part of the skulls of two individuals, one of them with thirteen vertebræ.

The vertebræ, which undoubtedly belong to the skull, have no lateral grooves, but the superior and inferior pairs of fossæ are present. The inferior fossæ are separated by a plane interval on the anterior centra, which rapidly narrows posteriorly. The centra are not elongate nor

contracted at the middle, and are sculptured with fine longitudinal grooves.

The cranium is depressed, and was so in life. The form of the muzzle is the extremity of an oval, at the apex of which are the two short premaxillaries, while the sides are composed of the long maxillaries. The top of the head is nearly smooth, marked only posteriorly by a few delicate radiating grooves and dots.

The inferior view displays the vomer, palatine, and maxillary bones with their myriad teeth *en brosse*. Those of the maxillaries form a narrow band, those of the premaxillaries a little wider one. The palatines are long flat bones similar to those of the *Stratodus apicalis*, but of less elongate proportions, and the teeth they bear are relatively smaller and not in longitudinal rows as in that fish. The teeth of the median line of the palate form an elongate tongue-shaped patch, flat and acuminate in front, but gently convex, and with lateral bevels more posteriorly. The teeth it supports are very close together as on the palatine bones. The posterior portion of this patch is broken away. The mandibular ramus is not deep and the symphyseal surface is a rectangular truncation of the nearly parallel inferior and superior edges. The teeth are in many rows, the number diminishing posteriorly. The dentary is incurved to the symphysis. The premaxillary bone is not smooth like the others of the cranium, but is pitted anteriorly, and radiately ridged posteriorly.

Measurements.		M.
Length of cranium		.102
Width of cranium behind		.050
Length of premaxillary bone		.015
Depth of the dentary		.009
Length of palatine bone		.052
Width " " "		.010
" " vomerine dentate patch		.010
Diameter of a cervical vertebra	longitudinal	.005
	transverse	.009
	vertical	.007

ANOGMIUS EVOLUTUS Cope.

This fish is represented by an entire left mandibular ramus. As corresponding parts are preserved in the typical specimens of *A. aratus* and *A. favirostris*, comparison with these species is easy.

The ramus is less curved than in either of the species mentioned, indicating an elongate and wedge-shaped head. The symphysis is short; deeper than wide, and but little incurved. The ramus is much contracted vertically at the glenoid cavity, which is deeply impressed and decurved on the inner side, having thus a convex transverse section. The angle is recurved behind the glenoid cavity, and also produced for a short distance in line with the inferior margin of the ramus, this portion being separated by a sinus from the superior process. The form of the angle is then that

of a boot with the toe elevated. The inferior edge of the inferior process is acute.

The inferior border of the ramus is thin. The superior border is thickened, and its tooth bearing surface descends on both the internal and external faces of the bone. Posteriorly, this face is presented inwards, but this tooth-band narrows forwards on this side, and widens on the external face. Its greatest width on the latter is posteriorly, an inch in front of the widest internal exposure; it then gradually contracts, its inferior border rising to a short distance behind the symphysis.

The dental alveoli are small and round, densely packed, and sub-equal in size. Near the middle of the ramus, thirty longitudinal rows may be counted. Not a tooth remains. A transverse section of the greater part of the length of the dentary is strongly convex; anteriorly it is flattened above.

Measurements.	M.
Length of ramus	.234
" " tooth band	.150
Depth of symphysis	.016
" at posterior end of tooth band	.050
" at glenoid cavity	.019
" at angle	.030

STRATODUS OXYPOGON Cope.

This fish is represented in Mr. Sternberg's collection by a dentary bone, a probable maxillary, and a portion of the palatine, both the latter without their extremities. A number of vertebræ accompany the jaws, which probably belong to the same individual.

The dentary is narrow and cuneiform, and rather robust for its depth. The tooth band is wide, covering more than half the vertical diameter of the bone, and is bounded below by a groove. The external face is convex. A delicate groove extends along the superior margin just below it; and a wide open groove commences behind the middle of the length and above the middle of the vertical diameter, opening widely behind. The inferior edge is compressed and flat, and is abruptly distinguished from the convex portion. The symphyseal surface is short, and the infero-anterior border is produced into an acute angle. The teeth are in six rows on the widest part of the band. Of these one contains larger teeth than the others; at one point it is the second from the external margin, but its position becomes more interior on the anterior part of the band. The teeth are recurved, round in section, and with simple, very acute apices. These are transparent and vitreous; the remaining portion of the tooth is opaque, and marked with whitish dots. At the anterior extremity of the dentary, but two rows of the smaller sized teeth remain.

The alveolar fossæ of the teeth of the three interior series of the dentary band, have a peculiar character. The internal half of the border has short radiating lines touching its circumference, but the external half supports

three convex lobes of dense tissue. The lateral of these are divergent and dorsal; the median is narrower, and is radial to the circumference. This structure does not appear in the alveolar fossæ of the three external rows. It is probably a hinge like attachment permitting elevation and depression of the teeth of the inner rows.

The supposed maxillary bone presents a wide open groove on both sides The superior border is convex in section and not so wide as the tooth bearing face, which is slightly oblique. But for this obliquity the section would be that of a T-rail. The groove of the internal face is continued further forward than that of the external face. There are six rows of teeth arranged as in the dentary bone, but in reversed order.

The fragment of palatine bone is densely packed with teeth, which are longer than those of the jaws. Their apices are as in the latter, simple. Those of one border are longer than those of the other, and the alveolar fossæ of these (the only ones I can see) bear the three adjacent tuberosities above described.

The vertebræ considerably resemble those of *Empo*. Their centra in both abdominal and caudal regions are elongate and contracted medially. There is a shallow longitudinal groove at the bases of the neural and hæmal arches, which are divided vertically by a median rib-like buttress. The median lateral portion is smooth or nearly so.

Measurements	M.
Length of dentary bone preserved	.0550
Depth " " " at middle	.0080
" " dentary tooth band at middle	.0050
" " " at symphysis	.0045
Length of maxillary bone preserved	.0530
" " " tooth	.0045
Depth " " at middle	.0060
Width " " " "	.0050
" " palatine bone	.0100
Diameter of an abdominal vertebra, longitudinal	.0160
Diameter of an abdominal vertebra, transverse	.0115
Diameter of an abdominal vertebra, vertical	.0125

This species differs from the *S. apicalis* in the simple form of the apices of the teeth. The type specimen is much smaller than that of *S. apicalis*.

Descriptions of Extinct Vertebrata from the Permian and Triassic Formations of the United States.

By E. D. Cope.

(*Meeting of the American Philosophical Society, November 2d*, 1877.)

The Triassic formation of North America has yielded many of the reptilian types which characterize the horizon in other parts of the world. A Labyrinthodont has been recognized in North Carolina, and I have determined the existence of the genus *Belodon* in the formation in both that State and Pennsylvania. Of *Dinosauria* three types occur in both Europe and North America. The *Palæosaurus* of the former country is represented by the American *Clepsysaurus*, and *Zanclodon* is somewhat similar in dental characters to the *Zatomus* of North Carolina. Of genera with compressed teeth which have a lenticular section, and both edges denticulate, *Bathygnathus* has been found in North America, and *Cladiodon* and *Teratosaurus* in Europe. This type has, however, been wanting heretofore from the extinct Triassic fauna of Pennsylvania and North Carolina. The present communication introduces it for the first time from the former State, under a form generically different from any of the preceding, and with the name

Palæoctonus appalachianus.

The specimens on which this determination rests, were found by my friend Charles M. Wheatley, A. M., in one of his copper pyrites mines. The most characteristic are two teeth which differ somewhat from each other in form. One of them has a greater transverse, and less anteroposterior diameter, indicating an anterior position in the series. The other is more compressed, and presents a greater anteroposterior width. Judging by the analogy of the genus *Lælaps*, this tooth occupied a position posterior to the first one. The two were found in close proximity, though not in actual contact, in a fragile, argillaceous portion of the copper-bearing rock.

The profile of the anterior tooth is regularly conic with a slight recurvature, which is not seen in the apex, but in the basal portion of the crown, and in the root. The section is almost semicircular at all points, but the inner and flatter face is slightly convex; rather strongly so at the apex. The denticulation of the edges is minute, measuring M. .00033. It continues to the base of the crown both fore and aft. At this point the edges are as elsewhere, at one side of the anterior and posterior aspects. There are no ridges nor facets on the crown, and the enamel possesses an obsolete minute rugosity of short linear ridges.

The crown of the second tooth is not only flatter and wider than that of the first, but is little more than half as long. Both edges are crenate to the base. The marked peculiarity of the tooth is seen in the division of the crown into facets by angular ridges. The convex face is divided into two, an anterior-looking and a posterior-looking, the former half as wide

as the latter. The angle separating them is not continued on the apical third of the crown. The section of the antero-external face is nearly plane. The division of the interior or flatter face is similar, but the angle is less pronounced. The anterior and narrower face is slightly concave. In this crown, as in the first described, there are weak transverse undulations near the basal third.

Measurements.	M.
Length of anterior tooth preserved	.080
Length of crown of same	.055
Diameter of base of crown { antero-posterior	.022
Diameter of base of crown { transverse	.016
Diameter near apex of same { antero-posterior	.010
Diameter near apex of same { transverse	.008
Length of posterior tooth preserved	.040
Length of crown of second tooth	.029
Antero-posterior diameter at base of crown	.025
" " at middle of crown	.019
Transverse diameter " " "	.010

These dimensions indicate an animal of the general proportions of the gigantic carnivorous *Dinosauria* of the genera *Lælaps*, *Megalosaurus* and *Teratosaurus*. They exceed those of the *Bathygnathus borealis* and the only known species of *Cladiodon*, *C. lloydii*.

The characters which demonstrate that this Saurian belongs to a genus distinct from any of the above are, Firstly, the presence of the external and internal longitudinal ridges which divide the crown of the posterior tooth into four facets. Second, the shortness of the crown as compared with its width, a point in which it approaches *Palæosaurus*. Thirdly, the semicircular section of the anterior tooth, a form not found in either *Bathygnathus* or *Teratosaurus*, where almost the entire series is known. It is only approximated in some of the Western species referred to *Lælaps*, but is not inconsistent with the characters of that genus as represented by them.

To the genus thus characterized, the name *Palæoctonus* is given, and to the species, the name *Palæoctonus appalachianus*.

Associated with the teeth of this species, were found several leaves resembling those of *Pterophyllum;* and stems of *Calamites* occur in the same locality.

Additional specimens received from Mr. Wheatley include anterior, intermediate and posterior teeth of a larger animal than the one above described, and intermediate and posterior teeth of a much smaller individual of probably the same species.

The large half-conical tooth of the large individual, presents a slight groove-like constriction at the basal portion of the posterior cutting edge. Length of crown above base .060; width at base .025. Width of posterior tooth at base .030. The form of the intermediate tooth is between those of the others. Its external face is very convex and is not faceted. The

approach of the external face to the anterior or cutting edge is much more abrupt than to the posterior.

The teeth of the smaller saurian only differ from the others in their size. The more posterior is probably anterior in position to those described above, as its external face is more convex, especially anteriorly, and is not faceted. Length of crown of the anterior tooth .032; width at base .019. Width of base of posterior tooth .015; length .019.

PALÆOCTONUS AULACODUS, sp. nov.

The teeth of this saurian differ from those of the *P. appalachianus* in having their basal portion sculptured with parallel shallow grooves. These are quite close together, leaving ridges between them which are narrower than themselves. The surface of the crown displays the silky sculpture of minute raised lines more distinctly than in the other species. But one tooth of this animal has been so far obtained by Mr. Wheatly, and this one is from the middle of the series of an animal rather smaller than the second individual of the *P. appalachianus*. In accordance with this position the crown is short and half conic with the external face strongly convex, most so in front. The denticles are well exhibited on both edges, but only descend on the anterior to the middle of the length of the crown. In both large and small specimens of P. *appalachianus* the denticles descend nearly or quite to the base. Length of crown .022; width at base .011.

CLEPSYSAURUS VEATLEIANUS, sp. nov.

Represented by a single large tooth in perfect preservation. In accordance with the characters of the type species, *C. pennsylvanicus* of Lea, the tooth is straight, and possesses two cutting edges. The posterior of these is denticulate and perfectly straight; the other is less extensive and is separated from the posterior by very unequal surfaces.

In the present saurian the tooth is compressed, and rounded in front, the section throughout the basal half being an oval with one end acute. The antero-interior edge only exists on the apical half of the crown, and is separated from the posterior edge by a somewhat convex face two-thirds the width of the external face. It is not denticulated, and its lower extremity falls behind the anterior margin of the crown when viewed in profile. The enamel is perfectly smooth. Length of crown from base of enamel layer .047; longitudinal diameter at base .018; transverse do. 011.

As compared with the *C. pennsylvanicus* of which several teeth are known, the *C. veatleianus* differs in its more compressed form, and in having the anterior cutting edge not denticulated. The position of this edge is more internal than in the longer known species, but this may indicate a more anterior position in the jaw.

This saurian is named in compliment to Charles M. Wheatley, A.M., of Phœnixville, Pa., to whose exertions we owe nearly all the material hitherto obtained from the Triassic formation of Pennsylvania.

SUCHOPRION CYPHODON, gen. et sp. nov

Char. gen. As no portion of the animals referred to this genus is known, other than teeth, the characters are derived from these only. Their crowns are elongate, conical and curved, and are furnished with denticulate cutting edges. In the teeth preserved these are separated by very unequal extents of surface, as they form the anterior and posterior borders of the inner face. The crown is penetrated by a very minute pulp cavity, and it consists of a number of distinct concentric cones.

It is probable that teeth have been discovered in Europe which belong to saurians of this genus, but I cannot find that they have ever received a distinctive name. They resemble those of *Crocodilia* rather than *Dinosauria*.

Char. specif. The only species of *Suchoprion* as yet known to me is represented by four teeth found in the same beds and formation as those above described. One of these is of large size, indicating that it reached the adult dimensions of the Gangetic gharrial. They display some difference in the degree of convexity of the external surface, which is sometimes opposite the imaginary plane of the inner face, sometimes oblique to it. The degree of convexity is always greatest at the base of the crown. The inner face is also convex. The curvature in the long direction is not great, and is directed to the inner side. The surface presents a minute silky sculpture; one tooth presents a very few shallow sulci.

Measurements.		M
Diameter of largest tooth	antero-posterior	.021
	transverse	.020
Length of crown of tooth No. 2		.045
Diameter crown tooth 2	antero-posterior	.009
	transverse	.016

BELODON CAROLINENSIS, Emmons.

Cope, Trans. Amer. Philos. Soc. 1869, p. 59.

Teeth of the anterior portions of the jaws were obtained by Mr. Wheatley.

BELODON PRISCUS, Cope.

Trans. Amer. Philos. Soc. 1869, p. 59.

Teeth from the anterior part of the jaws. In addition to the six species of saurians above noted, Mr. Wheatley obtained the tooth of a Stegocephalous Batrachian, probably a Labyrinthodont.

CRICOTUS GIBSONII, Cope, sp. nov.

While examinations into the Clepsydrops shale of Eastern Illinois have revealed a great abundance of individuals, and three species of *Clepsydrops*, the genus *Cricotus* has remained without addition, and the three vertebræ hitherto found, appear to belong to but one species, the *C. heteroclitus*. The present notice describes a second form, represented, like the first, by but few

remains. The vertebra which is best preserved, and which may be regarded as typical, is probably from the caudal series, and is thus well contrasted with the corresponding typical vertebra of the longer known species.

On this vertebra there is no trace of diapophysis, and the neurapophysis rises from the external side of the superior face. The wall of the neural canal is not preserved, but the inference is that the diameter of the latter is large. This fact and the absence of definite chevron articulations leads me to doubt the caudal position of the vertebra; but the usual marks of the dorsal and cervical vertebræ are totally wanting from it. As in *C. heteroclitus*, the *foramen chordæ dorsalis* is large, its diameter being one-third of the total. The articular faces descend steeply into it, that of one extremity more so than the other. The rim of the latter face is beveled outwards, the plane thus produced appearing on the inferior face something like the united faces of the chevron bones.

The centrum is a little deeper than wide, and the inferior face is truncate so as to give a subquadrate outline. The inferior plane is concave, the concavity being divided by a longitudinal rib. The sides are somewhat concave, with a longitudinal rib at the middle. Diameters of centrum: vertical .010; transverse .009; longitudinal .008. Width of inferior plane .005; width above, including neurapophyses, .008.

As compared with *C. heteroclitus* this species differs in the presence of parallel ridges enclosing a median fossa on the inferior side of the centrum. The small size may be here considered, but it is uncertain whether the two animals represented by the vertebræ are fully grown.

This reptile is named in recognition of the services of William Gibson of Newport, Ia., who has added a number of interesting facts to the geology of the Wabash region.

CRICOTUS DISCOPHORUS, Cope, sp. nov.

A vertebra, representing an animal as large as the *C. heteroclitus*, presents characters so much at variance with those of the latter as to require special notice. Three other vertebræ of smaller size present similar features.

The centrum is disciform, with very short antero-posterior diameter, which is, however, greater at one part of the surface than at the opposite point. The foramen chordæ dorsalis occupies about one-fifth of the transverse diameter, which is subequal in all directions. The articular faces of the centrum are slightly concave. The margin of that of one side is beveled for the superior two-thirds of the circumference, the bevel running out below by turning into the articular face. The latero-inferior border of the latter turns out into an obtuse angle at this point. The superior part of the bevel runs into the lateral face of the centrum. The attachment of the neural arch is obscure or wanting in the specimen, and the same is true of any facet for chevron bones.

Diameter of articular face	vertical	.025
	transverse	.025
Length of centrum below		.009
" " above		.007

Another vertebra of nearly the same character, and one-half smaller size, presents a greater difference between the long diameters of the upper and lower sides. The superior diameter is only one-half the inferior, and the foramen chordæ dorsalis much nearer the superior than the inferior margin. Its diameter is one-fourth the vertical and one-third the transverse diameter.

From the same locality and discoverer as the *C. gibsonii*.

LYSOROPHUS TRICARINATUS, Cope, gen. et sp. nov.

Char. gen. Vertebræ amphicœlian, perforated by the foramen chordæ dorsalis. Neural arch freely articulated to the centrum. Floor of neural canal deeply excavated. No processes nor costal articulations on the centrum, which is excavated by longitudinal fossæ. Centrum not shortened.

This genus resembles in the proportions of the centrum, the genus *Olepsydrops*, but differs in many details.

Char. specif. Two centra and a portion of a third represent this species. The former are a little longer than wide and a little depressed. The facet for the neural arch is an elongate plane truncating the border of the fossa of the neural canal on each side, for one-half to three-fifths the length of the centrum. Two deep longitudinal fossæ extend on each side of a median rib of the inferior face; and they are separated above by a narrower rib from another longitudinal fossa which is below the base of the neural arch.

Measurements.		M.
Diameter of centrum	longitudinal	.0055
	vertical	.0038
	transverse	.0040
Length of facet for neurapophysis		.0035
Width of neural canal		.0020

Discovered by Wm. Gurley, near Danville, Illinois.

DIPLOCAULUS SALAMANDROIDES, gen. et sp. nov.

Char. gen. Vertebral centra elongate, contracted medially, and perforated by the foramen chordæ dorsalis; coössified with the neural arch, and supporting transverse processes. Two rib articulations one below the other, generally both at the extremities of processes, but the inferior sometimes sessile. No neural spine nor diapophysis; the zygapophyses normal and well developed.

The vertebræ of this genus much more nearly resemble those of a salamander than any hitherto found in this formation, but it will be necessary to observe the cranium before this point can be determined.

Char. specif. One of Dr. Winslow's and two of Mr. Gurley's sendings contain vertebræ of this species. One from the latter gentleman is contained in a mass of clay in immediate contact with a mandibular ramus which supports a number of teeth. The ramus appears rather too

large for the animal to which the vertebra pertained, but the proportion is not different from that which I describe below in the genus *Eryops*.

The surface of the centrum is smooth and is without grooves. The diapophyses and parapoyhyses are rather elongate, and are closely approximated one above the other. The superior process issues from the centrum opposite the superior margin of the articular faces. They stand equidistant from the extremities of the centrum, and are directed obliquely backwards. The anterior zygapophyses occupy the same level. The neural spine is a compressed longitudinal ridge; it divides behind, leaving a notch between the posterior zygapophyses.

Measurements.		M
Diameter of centrum	longitudinal	.0060
	vertical	.0025
	transverse	.0025
Depth of centrum and neural arch		.0060
Width with transverse processes		.0070
Expanse of posterior zygapophyses		.0050

The mandibular ramus which accompanied one of the vertebræ is shallow and stout. Its external surface is sculptured with sharp longitudinal ridges, which inosculate more or less. The teeth have cylindric roots which occupy shallow alveoli sunk in a plane surface. The crowns are rather elongate and compressed near the apex, and without grooves or serræ. In contact with the jaw is an osseous fragment with a pitted or reticulated surface.

Depth of ramus	.0030
Length of crown of tooth	.0023
Four teeth in	.0040

ERYOPS MEGACEPHALUS Cope gen. et. sp. nov.

Char. gen. The details of the structure of this genus are derived from an almost entire cranium with underjaw, which is accompanied by numerous vertebræ and other bones. The form is Labyrinthodont, and embraces the largest species of that group yet known from this continent.

The skull is not elongate, and the quadrate bones are produced far backwards. The epiotic processes are present but not remarkably elongate. The temporal fossa is covered in by the usual roof. The orbits are round, posterior in position, and small. There is no postorbital depression or groove, and the lateral epiotic sinus is not deep. The nostrils are large and widely separated. There is no angular process of the mandible. The maxillary teeth are of different sizes, although arranged in a single row. The posterior are small and not closely placed; large teeth appear anterior to the middle. The premaxillary bone supports a number of large teeth. Those of the mandible which are visible in the specimen in its present state, those opposite the nares, are of medium size. The form of the crowns of the teeth is conic, with weak fore and aft cutting edges. There

are no distinct fissures of the surface although these may be represented by some fine parallel lines.

Vertebræ referred to this genus are small in proportion to the dimensions of the skull. They are not discoidal but somewhat elongate; are biconcave, and are not perforated for the notochord. The middle portion of the centrum is contracted. One articular extremity has the borders of the concave centre, convex. Zygapophyses large. Ribs present short; neural spines elongate, stout.

In comparing this genus with those described by authors and arranged by Mr. Miall in his family *Euglypta*, its exclusion from the latter is evident in view of the absence of angular process of the mandible, and the nondiscoidal vertebræ. Its posteriorly placed orbits distinguish it from the genera of his second family, the *Brachyopina*, excepting perhaps *Rhinosaurus*. It is with the genera of the third family, the *Chauliodonta*, that affinity appears to exist. It is unnecessary to compare *Eryops* with *Loxomma*, which has immense and irregularly shaped orbital openings, and trenchant teeth; but with *Zygosaurus* and *Melosaurus* the affinity is closer. The deep postorbital depressions, and the grooved maxillary teeth, described by Eichwald in the former genus, separate it at once. The teeth of *Melosaurus* are equally distinct, being, according to Meyer, conical and deeply grooved at the base. In *Rhinosaurus* the maxillary and mandibular teeth are said to be sub-equal. *Leptophractus* has deeply grooved teeth with strong cutting edges.

Char. specif.—In this category I include many of those introduced into the generic diagnosis by Mr. Miall in the very useful report to the British Assoc. for the Advancement of Science, 1874, p. 149, by the Committee on the Structure and Classification of the Labyrinthodonts. Such are the width of the interorbital space, the outline of the muzzle, the details of the sculpture, the approximate number of the teeth, etc.

The cranium has a sub-triangular outline, with the sides a little longer than the base, and the apex (muzzle) very obtuse. The profile is elevated behind, and the sides slope steeply to the mandible; the slope of the muzzle is rather steep, but less so than that of the cheeks. The extremity of the snout is broadly rounded and depressed, and overhangs the mandible. The supra-occipital outline is concave, and the epiotic angles only moderately prominent. The quadrate bones extend far posteriorly, and are horizontal above at their distal extremities. The orbits are nearly round, although somewhat wider than long, and they are directed equally outwards and upwards. The inner margin is slightly flared upwards, and it terminates anteriorly and posteriorly in a slight tuberosity, at the junction with the canthus rostralis and temporal ridge respectively.

The orbit occupies the anterior portion of the posterior third of the length of the skull, including the epiotic angles; and its long diameter is one-seventh that of the skull from the epiotics to the muzzle inclusive. The same diameter is about half of the interorbital width. The parietal region is plane, the frontal gently concave, and the muzzle depressed convex

in cross-section. The face in front of the orbit is concave below the canthus rostralis. The nostrils are not large, and are sub-round. They are widely separated, being nearer the maxillary border at its junction with that of the premaxillary, than to the median line. The mandible is shallow, and not very stout. Its inferior border rises from below a point a little in front of the fundus of the epiotic sinus to the angle, which is at the quadrate articulation. Symphysis short.

The sculpture of the anterior portions of the muzzle is coarsely punctate; on the posterior portions of the upper and lower jaws it is ridged and pitted. Most of the upper surface of the skull is still covered with a thin layer of the matrix, so that the sculpture and the character of the lyra, if any there be, remains unknown.

The teeth, as has been observed, are not visibly grooved, but the characteristic feature of the group may be represented by numerous delicate crack-like lines which one sees on the basal portions. These, however, look like the result of weathering. The sections of all the teeth would be round, but for the cutting edges, which are not very prominent. In addition, the premaxillary teeth are coarsely fluted on the median half of their length. The fluting is not visible on an antero-lateral mandibular tooth, nor on a posterior maxillary tooth. The microscopic structure of the teeth is not yet investigated.

The bodies of the vertebræ have concave sides, and a sub-round section. Their neural spines terminate in an obtuse enlargement. Many of the characters of the vertebral column are yet concealed in the matrix. The distal portions of the ribs are straight, cylindric, and become stouter at the extremity.

Measurements.	M.
Length of cranium from the extremity of the os quadratum	.433
Length of cranium on middle line	.335
Length from end of muzzle to nostril	.073
Width of cranium between quadrates	.306
" " " epiotics	.118
" " " orbits	.086
" " at orbits	.294
" " between nares	.085
Diameter of orbits { antero-posterior	.048
Diameter of orbits { transverse	.057
Length of premaxillary tooth	.025
Diameter " "	.007
Length of posterior maxillary tooth	.010
Diameter of median " "	.007
Length of a dorsal centrum	.024
Vertical diameter of do.	.025
Elevation of neural spine of do.	.050
Length of rib on curve	.080

This interesting fossil was found in the Triassic formation of Texas by my friend Jacob Boll. The cranium and vertebræ were discovered in such relation as render it evident that they were parts of one animal.

STRIGILINA GURLEIANA, Cope, sp. nov.

This species is known by a single jaw or tooth in complete preservation, which was found, like the type of the genus *S. linguæformis** near Danville, Ill., by Mr. Gurley.

The tooth is quite small, its length only equaling the width of the known tooth of *S. linguæformis*. It is also narrower in proportion to the length. The root and the cutting edge are turned in opposite directions as in the other species. The principal difference between the two is seen in the character of the transverse ridges or crests of the oval face. There are two crests less, or five, with a delicate basal fold, making six, while, counting the fold there are eight in *S. linguæformis*. The anterior ridge is transverse; the others slightly convex backwards, and all are equidistant and uninterrupted, which is not the case in the older species. They are also of different form, being distinct ridges with anterior and posterior faces similar. In *S. linguæformis* the anterior face only is vertical, the posterior descending very gradually, the whole forming a series of steps. Length of ridged face .0060; width anteriorly .0035; width posteriorly .0020.

This species is dedicated to William Gurley, of Danville, Illinois, to whose zeal science is indebted for the species from that locality described in this and other papers.

Twenty species have now been obtained from the Clepsydrops shales, the exact geological position of which remains to be accurately determined. Dr. Winslow informed me that they are the bed No. 15 of Prof. Bradley's section of the Carboniferous rocks of Vermilion county, Illinois. This places them near the summit of the Carboniferous series, below two thin beds of coal (which word is misprinted "coral" in my last paper, Proceed. Amer. Philos. Soc. 1877, p. 63). I am now informed that this portion of Prof. Bradley's scale is not correct, and that No. 15 occupies a much higher position than he assigns to it. It lies unconformably above the merom sandstone of Mr. Collett, which deposit is above the coal measures and unconformable to them. The stratigraphical evidence is thus conformatory of that derived from paleontology, that the *Clepsydrops* shale occupies a position in the scale above the coal measures.

CTENODUS PUSILLUS, Cope, sp. nov.

Form narrow, the width of the base about equal to the depth. The coronal portion is narrower than the base, because the inner face is oblique, forming an acute angle with the inferior plane. There are but four crests, of which the two longer are directed in one direction, and the two shorter in another. The interior ones of both pairs form a continuous

* Proceedings Amer. Philos. Soc. 1877, p. 52.

crest which is convex inwards. The crests are straight, elevated and acute; each one supports two or three denticles, which are rectangular and little elevated. The longer ones project beyond the general outline; the shorter ones are less prominent at the extremities; all are obtuse in the vertical direction. The superior surface is smooth. The inferior is slightly concave in the transverse sense. The tooth on which this species is found is the smallest yet obtained from the formation. Length, .007; width, .003; depth at inner crest, .003.

Two specimens were found by Wm. Gurley, in Vermilion Co., Illinois, in the *Clepsydrops* shale.

I have referred two species from this formation to the genus *Ceratodus*, under the names of *C. vinslovii* and *C. paucicristatus*. While the form of these teeth is that of the genus named, the structure of the superficial layer differs in wanting the punctæ which are characteristic of *Ceratodus*, but is, on the contrary, uniformly dense, although frequently irregular. I therefore refer the two species above mentioned to another and allied genus, under the name *Ptyonodus*, with *C. vinslovii* as type.

ORTHACANTHUS QUADRISERIATUS, Cope, sp. nov.

Represented by an incomplete radial spine. With it occur several fragmentary spines which resemble very closely one belonging to *O. gracilis*, Newb. (Geolog. Survey of Ohio, Pl. lxix, fig. 7), and which only differ in having the denticles shorter. As teeth of a *Diplodus* near to or identical with *D. compressus* are common in the shale, the two may belong to the same fish. Dr. Newberry has already suggested that *Orthacanthus* and *Diplodus* are identical.

The *O. quadriseriatus* is quite different from the other species. The spine is wider than deep, and the series of denticles are widely separated. The surface between them is gently convex and smooth. The anterior face is strongly convex and presents at each side two shallow furrows. The external groove is divided by a series of thin longitudinal denticles which are smaller than those of the principal row, and which are sometimes somewhat confluent at the base. The principle denticles are closely placed, stout, acute, and recurved. Transverse diameter of shaft .0035; antero-posterior diameter .0025. The portion of the shaft preserved is straight.

ARCHÆOBELUS VELLICATUS, gen. et sp. nov.

"Species No. 4," Cope, Proceed. Amer. Philos. Soc. 1877, p. 55.

Several other specimens of the body described as above have been obtained by Messrs Winslow and Gurley. In every instance it is a tooth-like process attached to a solid base by anchylosis in the manner of the teeth of fishes. From the appearance it presents I am led to suppose that it is the only one of its series, and there are none of the numerous teeth of the collections which can be associated with it. I therefore distinguish the genus by a name and the following diagnosis.

The form is conical, and the surface is not grooved nor furnished with

prominent ridges. The interior is hollow, and the walls are composed of a few concentric layers without external enamel or cementum. The solid base to which it is attached is shallow, presenting smooth surface on the opposite side, which is deeply impressed by a longitudinal groove at one end.

The characters of this species are pointed out at the place above quoted. The measurements of a large specimen are: length .015; diameter of base, long .008; short .005.

I am not sure as to the part of the skeleton to which this body should be referred.

CLEPSYDROPS LIMBATUS sp. nov.

The discovery of a species of the genus *Clepsydrops* in Texas, in a formation hitherto regarded as Triassic, adds weight to the view above expressed, that the *Clepsydrops* shales of Illinois belong either to the Triassic or Permian formations. As typical of the new species I select a vertebra, which may be exactly compared with corresponding one of *C. collettii*. The centrum is about as wide as long, and its sides are very concave, much more so than in *C. collettii*, and the rim-like borders of the articular extremities are connected by a straight compressed hypopophysial keel. The sides of the foramen chordæ dorsalis are convex in the longitudinal section, thus contracting the opening, as compared with the very wide flare of the border of one of the extremities of the centrum. This flare receives the wide recurved border of the opposite extremity of the adjoining centrum, forming a kind of ball and socket articulation. This reflected surface forms a ridge with the funnel of the foramen at this extremity of the vertebra. The concave extremity is produced downwards, so that the foramen is considerably above the middle point. The diapophysis and parapophysis are not distinct nor elongate, but are represented by a projecting scar on the superior part of the centrum, which is directed downwards and forwards towards the rim of the articular face.

Besides the great contraction of the centrum, its relatively shorter form distinguishes it from that of *C. collettii*. It is also much larger than that species and the *C. pedunculatus*, being the largest of the genus.

Measurements.	M.
Length of centrum	.031
Diameter of centrum { vertical	.039
Diameter of centrum { transverse	.033
Width of neural canal	.006

Discovered by Jacob Boll.

On Reptilian remains from the Dakota Beds of Colorado.

By E. D. COPE.

(*Meeting of American Philosophical Society, November* 2, 1877.)

Since the discovery of the huge saurian *Camarasaurus supremus* (Cope, Paleontological Bulletin, No. 25, p. 5), Superintendent Lucas has explored

the horizon of the Dakota of the Eastern Rocky Mountains near the Arkansas River for other indications of extinct life. His search has been rewarded by the finding of several species of reptiles of interesting character, which it is the object of the present paper to describe.

CAULODON DIVERSIDENS gen. et. sp. nov.

This large saurian is represented by ten teeth found together, but separated from the cranial bones, and in a more or less broken condition. I select four of these exhibiting the characters most clearly.

Char. gen. Fang of the tooth of great length and hollow, and contracted at the base. It is without excavation for successional tooth. Crowns of the teeth of different forms in different portions of the jaw; the posterior are like the bowl of a spoon; others have a similar form but are more compressed, having double lateral ridges, while the crown of another, supposed to be an incisor, is little wider than the root, and has the section an oval with one side less convex than the other. All are coated with an enamel-like layer of considerable thickness which extends on the fang in some of the teeth. None of the crowns present cutting edges.

The characters presented by these teeth are quite distinct from anything hitherto found in North American Saurians. The absence of indication of the successional teeth is remarkable, and in connection with the contraction of the base of the root, suggests that the mode of succession of teeth approximated that exhibited by the *Mammalia*.

Char. specif.—The roots of all the teeth are cylindric. The crown of the posterior tooth is convex on one (the external) side, and concave on the other. The convexity is increased by a contraction of the external surface near and parallel to each border. The concavity is divided by a longitudinal rib which disappears at the base. This edge of the crown is obtuse, as is also the apex. The outline of the apex is rather broadly acuminate. The enamel is closely and strongly rugose, longitudinally on the base, transversely at the edges, and reticulately on the middle portions of the crown.

Measurements.	M.
Length of crown with portion of root	0.120
Diameter of root at middle	.025
Length of crown	.055
Diameter of crown { longitudinal	.030
Diameter of crown { transverse	.020

The crown of the second tooth is a little less expanded laterally, and has a greater transverse diameter. The outer side is more convex, and there are two marginal ribs on the basal half of the crown. The interior are not strictly marginal, but are situated within the exterior ribs. Both are very obtuse, and they are separated by a shallow groove. There is no median longitudinal rib.

Measurements.	M.
Diameter of crown at middle { antero-posterior	.026
Diameter of crown at middle { transverse	.018

The third type is smaller in all its dimensions, and the crown is equal to the root in long diameter. In my single specimen the distal portion of the crown is lost; the part which remains exhibits neither contraction nor expansion of outline. The borders are very obtuse, and each surface resembles a roll inwards which is bounded by a shallow parallel groove on the inner face of the tooth. Between the grooves the surface is slightly convex. The section is thus an oval with one side very little convex. The enamel is thick and marked with longitudinal rugosities.

Measurements.		M.
Length of fragment		.060
" " root		.030
Diameter "		.014
Diameter of crown at middle	longitudinal	.0135
	transverse	.0085

TICHOSTEUS LUCASANUS, gen. et sp. nov.

Char. gen.—The characters of this genus are derived primarily from the vertebræ. They are nearly amphiplatyan, but one extremity of the articular face is slightly concave, while the other is still more slightly convex or concave. The borders of the former are expanded, while those of the latter are not enlarged. The centrum is hollow, but the chamber does not communicate with the external medium by a lateral foramen, as in *Camarasaurus*. The neural arch is attached by suture. There is no capitular articulation on the centrum.

Char. specif.—There is no hypapophysis on either dorsal or lumbar vertebræ preserved, and the surface is smooth excepting some delicate longitudinal ridges extending to the border of the expanded extremity. The narrower extremity of a dorsal vertebra is nearly round and presents a slight median tuberosity; the opposite end is wider than deep, and its surface is uniform. The smaller extremity of a lumbar vertebra is slightly concave.

Measurements.		M.
Diameter of dorsal centrum	longitudinal	.023
	vertical	.020
	transverse	.025
Width of base of neural arch with diapophysis		.010

This species is dedicated to its discoverer, O. W. Lucas, of Canyon City, Colorado, the Superintendent of the Public Schools of the surrounding region. Through the scientific interest and energy of this gentleman the extinct vertebrata of the Dakota division of the Cretaceous Period hitherto unknown to science are being brought to light. The care and skill exercised by Mr. Lucas in the preservation of remains, which are often bulky, and always fragile, deserve the thanks of all students of this department of science.

COMPSEMYS PLICATULUS, sp. nov.

Although tortoises have been discovered in older formations in Europe, the present species is the earliest yet obtained in North America. Its characters appear to coincide in important respects with those of the Lignitic formation which I have referred to *Compsemys* Leidy. This name I have proposed to retain for tortoises with marginal bones completely united with solid plastron, and the usual dermal scuta, and which differ from *Emys* in their Trionyx-like sculpture.

The *C. plicatulus* is represented by portions of both carapace and plastron of several individuals. While the distal extremities of the costal bones display the suture for the marginals, they also possess an inferior true costal prolongation, as in Trionyx. The proximal part is not preserved in any marginal bone, but the adjacent portions were united by fine suture. The proximal extremity of the costals exhibit the usual two directions, the shorter being posterior, and relating to the anterior part of the succeeding vertebral bone. The sternal sutures are fine; that between the hyo- and hyposternal bone is transverse; while that between the latter and the post-abdominal is oblique, and at the margin quite squamosal. At that point the hyosternal underlaps the post-abdominal for a considerable distance, and the suture of the inferior side of the plastron, after bending forwards, is abruptly recurved, running along the edge of the posterior lobe.

The scutal sutures are not wide nor deeply impressed, but the abdomino-femoral, and the femoro-anal are distinct. The median, longitudinal, sternal, and the costo-marginal sutures are irregular and serpentine. The sculpture is rather fine, and consists of rather closely placed tubercles and ridges. The borders of the elements of both carapace and plastron are marked with ridges at right angles to the sutures, which are not short. The middle parts of the costal bones are marked by short interrupted or inosculating vermicular ridges closely placed. On the middle portions of the sternal bones the ridges are in places more broken, forming tubercles.

The surface of the bridge is angularly oblique to that of the plastron. The buttresses are not produced inwards. The free marginal bones are rather thin, and are not recurved.

Measurements.	M.
Length of a costal bone	.110
Width of the same	.032
Thickness "	.005
Length of hyposternal bone	.066
Width of the same at inguinal notch	.048
Thickness of the same in front	.007

Found by Superintendent Lucas with the foregoing species.

Sylviculture.

By Eli K. Price.

(*Read before the American Philosophical Society, November* 16 *and December* 7, 1877.)

By the will of André Francois Michaux, the American Philosophical Society is, to the extent of the means afforded by his legacy, charged with the trust, to contribute in this country "to the extension and progress of agriculture, and more especially in Sylviculture in the United States." This Society, also, by its Charter is under the obligation of diffusing useful knowledge; and few subjects can be more useful than the cultivation of trees.

It becomes us, therefore, to consider how we can promote the cultivation of trees in this country; how make that cultivation subserve the interests of agriculture: and in what manner, and how widely we may fulfill these duties, and diffuse useful knowledge upon these subjects.

Mr. Michaux, as well as his father, spent his life in acquiring knowledge of trees, and wrote his volumes to describe them, not only to promote science, but to teach their uses and value as timber. He has intended that we should do more. He intended that we should promote the growth of trees, and also extend the growth of agriculture; by the influence of tree-culture upon climate, soil and the water supply, whereby to increase the food of man and beast, and thereby to multiply the population of the world.

In a revoked will he had suggested the purchase of land, and the planting of it with trees. In this he no doubt intended the exhibition of many varieties of kinds to give a scientific knowledge of them, and also intended that the groves there planted should be a centre of distribution of trees and their fruits. This idea has been held in view by this Society when it placed half the income of the legacy at the disposal of the Fairmount Park Commissioners, for the purchase, planting and distribution of trees and tree seeds. With half the income applied in this manner a more extensive good can be effected than by a separate application of the whole by the Society, which would of necessity have been at a more distant place, to be seen by a few only in the time that a thousand will see the trees in the Fairmount Park, and obtain their seeds. In that Park the name of the Testator has been honored by the plantings commenced in the "Michaux Grove," while thousands of trees procured by his provision are in the Nursery, waiting to be transplanted over the Park, of nearly three thousand acres, and elsewhere. These add to the variety of our plantings, and to the self sown trees of the native woods, thus adding increased attractions for botanists and lovers of the landscapes.

When Mr. Michaux extended his views to agriculture in connection with tree-culture, we must believe that he had in mind the influences of trees

upon climate, the supply of rain and retention of water as means of growth of grass, the cereals and other crops. Let us consider then what are those influences, and how far, as beneficent, they are within the control of man; not that the means placed at our disposal by Mr. Michaux, can, in the trees they will plant, soon greatly influence climate, soil and rains; yet by affording a perpetual source of supply of trees, a perpetual example and diffusion of knowledge to others, no one can prescribe limits, in space or time, to the good these limited means may effect.

The Society will, therefore, I think, pardon me for taking a wide survey, for it and all others to fill in its outlined work, according to the measure of their ability, and in the aggregate, all may do a great good, that would not be attempted if the sphere of operation were not widely opened, and the necessity of co-operative action, and the ways and means of success, were not explained, to be kept in view at present, and in a long future. With our duty mapped out, we and our successors will see the surveyed field of operations, and will be stimulated by the grandeur and beneficence of the prospect opened for good to our fellow beings.

It cannot be doubted that Nature will ever willingly do her part of the work if not thwarted by man; nay, will do it exuberantly. The great need is to regulate and restrain his excess of destruction. Before man came upon the earth it had been densely covered by vegetation; hence its pervading coal measures, lignites, and stores of oil that have been preserved under the rocks to await the age of human intelligence necessary to develop them. In that age happily we live.

We may well believe that the earliest of our race found our world covered with forests; except in those places unfitted for their growth. These were the polar regions, where ice cuts off the growth of trees; the mountain crests where both cold and want of soil prevent all growth of trees, and arid deserts. Whether we may give trees to the deserts is only a question of procuring water and soil. Yet the seemingly barren lands cast up by the sea can be made to bear forests, and to flourish in vegetation.

Before man's appearance, the great enemies of forest life did not exist. He alone could invent the axe and light the fire. Forests were then in excess of man's needs, and were utilized in fossil coal. What evil he has done with the axe and fire, and how such evil may be repaired, we have to consider. True, the woods grow for legitimate uses; for timber, for habitations, the mechanic arts and fuel; but not for wasteful destruction. They must also be felled for needful space and soil to grow the food that man and beast may live; but not destroyed to an extent to put the supply of the food of life in peril; or to so lessen it as to lessen population. In regions covered with timber capable of tillage, in excess of that point which will support the largest population in prosperity, clearing, without waste of what can be utilized, becomes a duty; but to exceed that point is a wrong to humanity. In this we have the practical test that the wise and good will observe. Life to the greatest number of happy people is the moral and scientific problem and test of duty, as we must believe that such purpose was the intent of the Creator.

Taking in hand the light of History, let us pass over historic grounds to see what man has done to destroy the forests, and how and where he may prevent and remedy such devastations. Beginning at the supposed cradle of our race, we find in the books of the Bible and contemporary histories frequent mention of the presence of forests, the coverts of wild beasts, and accessible woods to answer instant requisitions for timber for building houses, bridges, towers and rams; of trees for shade and fruit, and fuel; and branches of trees upon which to hang malefactors. There were the cedars, firs, shittim wood, terebinth, sycamores, and oaks, upon mountains and plains, and the sacred groves upon the hills where the heathen worshiped, in a measure protected as sacred by religion and superstition; but in after time these were unavailing to save them. The fig, the date, the palm and the olive were better preserved, as necessities for food, and willows sprang spontaneous along the edges of the water.

Hesiod lived about a thousand years before Christ. Speaking of Peace, Justice and Prosperity, he says:

"No days of famine to the righteous fall,
But all is plenty, and delightful all;
Nature indulgent o'er their land is seen,
With oaks high towering are their mountains green;
With heavy mast their arms diffusive bow
While from their trunks rich streams of honey flow."

Thus described were they as seen, as he watched his flock and courted the Muses on Helicon. And again Hesiod describes a wooded country when he speaks of the north wind; says of it:

"Bellowing through Thrace, tears up the lofty woods,
Hardens the earth, and binds the rapid floods!
The mountain oak, high towering to the skies,
Torn from his roots across the valley lies;
Wide spreading ruin threatens all the shore,
Loud groans the earth, and all the forests roar."

The beasts;

"Through Woods, and through the shady vale they run
To various haunts, the pinching cold to shun:
Some to the thicket of the forest flock,
And some, for shelter, seek the hollow rock."

Evelyn cites with satisfaction that when Xerxes passed conqueror through Achaia, he would not suffer his army to violate a tree; "it being observed by the Ancients that the gods never permitted him to escape unpunished who injured groves."

Near five hundred years before Christ, Eschylus makes the Chorus sing to Prometheus Bound,

"Thy woes, beneath the sacred shade
Of Asia's pastured forests laid,
The chaste inhabitant bewails,
Thy groans re-echoing through his plaintive vales."

And nearly five hundred years after the Christian Era, Basil the Great

writing to Gregory the Great, from the Isis that empties into the south side of the Black Sea, thus describes his home in that part of Asia Minor: "A high mountain clothed with thick woods, is watered to the north by fresh and ever flowing streams. At the foot lies an extended plain, rendered fruitful by the vapors with which it is moistened. The surrounding forest, crowded with trees of different kinds, encloses me as in a strong fortress." Humbolt's Cosmos, 393.

Herodotus had thus nine hundred years before described the country further to the East. "This part of Media, towards Saspires, is high and mountainous, and abounding with forests; the rest of the country is a spacious plain."

Of the north of Africa Herodotus says, "All the more western parts of Libya, are much more woody, and more infested with wild beasts, than that where the Libyan Nomades reside; for the abode of these latter advancing eastward, is low and sandy. From hence westward, where those inhabit who till the ground, it is mountainous, full of wood, &c." (Ch. 99; Sec. 191.)

Libya, or the region called Tripoli, extending from Egypt to Tunis, in the early Christian centuries while under Roman rule, was productive and populus, and when overrun by the followers of Mahomet, towards the end of the eighth century, was reputed to contain six millions of souls, and eighty-five Christian Bishops (Dr. F. L. Oswald), and now probably not a million inhabit the same space. Elesée Recluse says that "the examination of the soil and the remains which are contained in it, proves that at a recent geological epoch, the Sahara was much less sterile than it now is. The Tribes of the Algerian Sahara say, that at the time of the Romans the Ouad-Souf was a great river, but some one threw a spell upon it, and it disappeared. (The Earth, 95.) That spell was an evil one, the destruction of the forests.

Dr. Oswald says, "On the plateau of Sidi-Belbez, in the very centre of the Sahara, Champollion traced the course of former rivers and creeks by the depressions in the soil and the shape of the smooth-washed pebbles. He also found tree stumps almost petrified, and covered by a six foot stratum of burning sand." He quotes Champollion as saying, "And so the astounding truth dawns upon us that this desert may once have been a region of groves and fountains, and the abode of happy millions. Is there any crime against Nature which draws down a more terrible curse than that of stripping Mother Earth of her sylvan covering? The hand of *Man* has produced this desert, and I verily believe every other desert on the surface of this earth. Earth was Eden once, and our misery is the punishment of our sins against the world of plants. The burning sun of the desert is the angel with the flaming sword who stands between us and Paradise." How certain, how sad, is this great truth! How awful then to think of the millions more who might have lived but for man's ignorance, and folly and wickedness; and to reflect upon the incalculable loss of happiness to those who did live, and have struggled with a deteriorated Nature for a miserable existence!

According to Cæsar and Tacitus, middle Europe was found by the Romans heavily covered with forests, and in Gaul and Britain were the deeply shaded woods where the Druids had practiced their gloomy religious rites, and offered in sacrifice the victims of their terrible superstition.

Now pass from eastward of Persia westward, and take a survey of both sides of the Mediterranean as far as the Atlantic ocean, and we behold countries on every hand stripped of their forests, with decrease of rains, with fallen rivers, extended deserts, and depleted populations. This change from plenty to poverty is justly ascribed mainly to the destruction of the forests, which exposed the lands to a burning sun. The waters were dried up, and the soil was washed away by floods, or driven off by the winds, or covered over by ever drifting sands.

The following are the percentages of woodlands left in the once densely timbered countries of Europe where forests have not been adequately protected: Naples, 9.43; Sardinia, 12.29; Italy, 20.7; Spain, 5.52; Portugal, 4.40; France, 16.79; Belgium, 18.52; Holland, 7.10; Denmark, 5.50; Great Britain, 5; Switzerland, 15; while Germany yet has 26.½; Russia in Europe, 40; Sweden, 60; and Norway 66 per cent. of their surface in forests.

The lessons taught us by the other continents of the Eastern Hemisphere, are both to avoid the cause of aridity, and to repair in time the mischiefs caused by man's improvidence. We have in the west our "bad lands," our natural deserts, grassless and treeless, for want of water, and our grass covered prairies, also treeless, which can only be made productive of trees by the presence of water, and the absence of fires. Waters must be had by rains, or be drawn from the earth, or saved in reservoirs or tanks, to be spent in irrigation. We also have our exhausted lands on the Atlantic seaboard, which only need rest from tillage, and to be sown with the seeds and planted with forest trees.

What we can do for these may be seen by observing what has been begun to be done in other countries, not more favorably situated, where men have yet life and energy sufficing to repair ancestral delinquency. France has taken alarm and has begun the work of reparation. John Croumbie Brown has published a book of 351 pages entitled, "Reboisement in France," in which he describes the evils suffered, and the remedies of prevention and restoration. He shows the effect of stripping the mountains in east France of their trees has been to increase snow and land slides, which destroying that set in motion, also destroys that swept over in the descent, and that covered by the deposit. When the rains come, or the snows melt, the torrents come quick, are rapid and resistless. They undermine the banks, and carry destruction with them. Nature here again begins the work of restoration by scattering the seeds of the forest, and men have learned the wisdom of co-operating with Nature, and of letting her more alone. They now protect the forests, and the forests promote "infiltration, retention, and percolation of water through the soil and subsoil, on which they grow." p. 38, 50. In other Departments the like

success has been attained as in the High Alps. Where the trees grow, the springs flow; where cut down the springs dry up, and the streams grow less in their channels. There is less rain fall, and the soil retains less of what falls.

On the west side of France from the Gironde to Bayone, are the *Landes*, or Sand-dunes, which are sands carried inland from the seashore by the winds, until they cover 2,500,000 acres, and threatened to engulf the departments of Landes and Gironde. These, however, have been planted with the pine and other trees, and the forests now protect the country behind them, and the sands have been considerably subdued by cultivation, and arrested in their inward progress.

In Algerian Africa the French Engineers, from 1856 to 1864, had dug eighty-three wells, which together yielded nearly twelve millions of gallons of water per minute, sufficient to nourish 125,000 palm trees. (The Earth, by Elisée Reclus, 95); so that even the desert may be made to yield fountains of water, and can be clothed with arborial fruit and verdure; and it may be in this way that our treeless regions of the Far West can be attacked by American enterprise. Our warm south and south-west would, with supply of rain and irrigation, yield greatly increased quantities of semi-tropical fruit and forest trees of most valuable kinds.

It is the work of reparation of the wrong that man has done to Nature, and the prevention of the repetition of such wrong, that must now be the subject of our consideration, practical action, and admonition to others.

Let us first be sure that we are acting upon a true theory. There are those who think that forests have but little or no influence in producing or attracting rains; men whose opinions are entitled to great consideration and respect. Yet we well know that whenever the currents of air, laden with the moisture of evaporation, strike the cooler mountains, rain is precipitated. So woods, we may believe, may be so elevated and cool as to produce showers from clouds charged near to the point of precipitation, as the dew falls by a slight difference of temperature between day and night.

Men in the valley or plain often do see clouds pass over them to fall as rain on hills and woods more elevated. We know too that countries have less rain-fall by reason of the deprivation of their forests. Travelers so report of Malta, the Cape Verde Islands, St. Helena, and in Aragua, Venezuela, according to Humbolt; and in Egypt, where the date palm and the olive have of recent time been plentifully planted, the rains have become more frequent: (Dr. Franklin B. Hough's Report to Congress in 1874, p. 21). Dr. Oswald reports that a rise has taken place in Egypt in the annual rain-fall, from 9 to 16 inches, since the increased planting of trees.

It is quite certain that trees preserve the waters in the ground, and maintain the flow of the springs and streams. If trees be felled, and the sun be let in, the ground is dried, and its moisture is carried away by evaporation instead of percolating into the earth to reach the channels of the springs, and these also dry up. If the springs fail, the rivulets must fail, and rivers must fall.

Reclus says, "Trees, after they have received the water upon their foliage, let it trickle down drop by drop on the gradually softened earth, and thus facilitate the gentle permeation of the moisture into the substratum; another part of the water running down the trunk, and along the roots, at once finds its way to the lower strata." (The Earth, 223).

The facts are abundant in proof that to part with the trees is to lose the springs they protect, the running streams the springs supply, and the volume of the broad river. These lost, all the charm of the landscape has fled, and then this source of man's refinement and civilization has also left the world. With loss of rains and springs the fruitfulness of the earth also passes away. Grass fails for flock and herd, and the bread of life for man is no longer sure, and only because man has betrayed his trust.

Australia affords corroborative testimony. In the *Tribune* of December 1st, I find this statement: "Mr. Landsborough, an explorer of note, says, 'Keeping sheep is no longer so profitable there as it used to be, but on the other hand, large tracts of land that were worthless before, have latterly become fit for agriculture. There is a decided increase of forests and of moisture in parts of Australia, giving hope that eventually the whole interior desert may be reclaimed. The direct effect of sheep-raising has been to keep down the tall grass which formerly afforded material for destructive fires. The trees, young and old, had been periodically burnt by these fires, until the country becoming almost treeless, its climate had been rendered arid and its soil sterile. If the facts in Australia can be established, they will afford the most remarkable instance yet recorded of climate being modified by the labors and surroundings of civilized man.'"

Trees, better than all else, protect the slopes from washing into gullies, and the loss of the soil by rains. A carpet of grass will do much to protect the earth from washing; but is not impervious to the beatings of storms, and the small beginnings of erosions ever enlarge their channels by undermining the roots of grass. The sides of our hills and the sodded slopes of railroads show this. The force of the unintercepted drops of the driving rains does the work of excoriation. The leaves of the sheltering forest break the force of the rain, and the arrested waters trickle in slow drops to the ground, and gradually soak into it without washing the soil. The covering of the fallen leaves also prevents disturbance of the soil, and the leaves growing above, and those dead below as well, intercept the rays of the sun, and check evaporation. The retained waters must find their exit by the springs.

The forests in due proportion are also shelter and protection of the growing crops of the farmer from the force of driving storms. They are a shelter for grazing cattle, and shelter for house and barn, and man and beast thus kept warmer thrive better. Trees also shelter trees, and northwardly planted belts largely increase the growths of nurseries and orchards.

Now what is the due proportion of woodlands? A Duke of Burgundy's rule, as quoted by Dr. Oswald, is, "One-third to the hunter, two thirds to the husbandman." William Penn's direction to his colonists was, that

"in clearing the ground care be taken to leave one acre of trees for every five acres cleared; especially to preserve oak and mulberry trees for silk and shipping." His father, Admiral Penn, would have included in it "shipping," for the purpose of maintaining a navy; still an object of our statesmen so far as iron has not superceded wood.

Thus William Penn's rule was to leave one for five acres cleared, or 16⅔ per cent. of wood appendant to each farm; of course, so much besides the wooded hills, sand-dunes and mountain tracts. For the entire country, and for the general good of forestry and agriculture his proportion of woodland is probably something too small. The proportion of woodlands in the entire area of these *States*, taking into consideration water surface, cities, highways, &c., is 29 per cent.; including Territories, is 25 per cent.; showing a disproportion of our Territories to be woodless.

Dr. Hough gives the rule of proportion of wood with reference to the true test. He says "There can be no doubt but that injuries may result, as well to agricultural interests as to the public, from an excess of forest growth. It is the highest aim of forestry to attain the golden mean between too much and too little, and on this due balance of field and grove depends that equilibrium of health and wealth that promises the greatest amount of human happiness to the greatest number, and through the longest period of time." Report, p. 32.

It is impracticable to bring the different States or sections of the United States to approximate any uniform standard as to the proper proportion of woodlands. It would generally be unprofitable to attempt to make arable, steep, stony and rough mountain lands, or poor sandy tracts, or deep swamps and ever-glades. But it is the interest of all to keep these wooded, and to reforest the lands worn out by cropping, that they may not become dry deserts. But every vast continuity of forest should be broken for agriculture, intercourse and security of health, property and life, and regions of prairie and deserts be made to bear a due proportion of forests.

And farm lands should be interspersed with trees to preserve them in the best agricultural condition. To do this, few farmers, though they draw their fuel from the mines, are inclined, by planting areas of cultivated or pastured fields. This they would not consider economical. But they could with little loss of useful space, plant the most sunny side of every road passing through their farms, and thus the farming soil would be little shaded, and the roots of the trees draw the greater part of their nourishment from the soil under the highway. The public would be gainers in grateful shade, and the farmers would have the protection of the roadside trees and their shade; and finally, their use as timber as they come to maturity, and are replaced by renewed plantings. To do so much, an enlightened self-interest should impel them.

In addition let every farmer keep open and flowing all his springs for drink for his herds and flocks; plant around them groves of trees, both to preserve the flow of the water, and to afford shade to man and beast.

Every railroad company should plant trees on the sunny side of their line

of tracks for shade, and for cross-ties and car timber, against the time when lumber will surely become more scarce; and should, for its best self-interest, use every device to avoid firing the forests, and use cross-ties that have been barked, creosoted, kyanized, or saturated with boiling tar. The interest they have at stake to economize is incalculable.

Legislation is not here suggested, except it be to authorize the roadside planting; and, perhaps, counties to offer rewards for such planting. The functions of our Society in regard to tree planting are two: to diffuse useful knowledge, and to execute the trusts of the Michaux legacy, yet this is to co-operate in a sphere of action that is boundless and endless. True, our fund is small, but held by a perpetual trustee, its munificence should be perpetual; its beneficent effects never cease to spread, and the knowledge we impart and incentive we give, may bring sympathetic and enduring aid by many others, by the States, and the United States.

When we consider that trees require the growth of many years; that large tracts of country are denuded, which can be more profitably used by reforesting than otherwise, and that to make the reforesting useful and profitable, there must be choice of trees, and skill in the manner of their management and care, we must see that no time should be lost. This generation should begin the work effectively, and enjoin the duty upon those to follow.

The kinds of trees to be preferred by considerations of durability and their multifarious uses, are the American White Oak; the American White Pine; the American White Ash; the American Elm; the Chestnut, Walnut, Hickory and Larch. To this list of trees is to be added the Eucalyptus, or Blue Gum, of Australia, for its anti-malarial properties, and for its rapid growth, yet excellent timber. Its wood is white, about as hard, but a little stronger than the best Eastern Ash. (J. T. Stratton, Agl. Reps. of '75, p. 345). The planting and management must be left to professional skill.

The Massachusetts Society for Promoting Agriculture, who received two-fifths of the Michaux Estate, have offered prizes for the cultivation of plantations of not less than five acres, to be planted with the European Larch, Scotch and Corsican Pine, and American White Ash. The competition will be likely to exact the use of farm lands, while agricultural economy requires the chief sowing and planting of trees to be on the stony places, and profitless sandy spots, such as are often savingly allotted to bury the dead. These too may be planted with economy and pleasing effect.

Annexed to their circular is a very valuable Essay by Professor C. S. Sargent, Director of the Botanic Garden and Arboretum of Harvard University. This I have read since writing the preceding pages, and the facts and opinions by him expressed, sustain the foregoing views. He shows by sufficient testimony that woods do produce rainfalls; do preserve springs and rivers; do protect the soil and crops, nurseries and orchards; that sandy lands though exposed to the fierce winds of the seashore, have pro-

duced largely in Massachusetts, the Larch and Scotch Pine, besides Oaks, Ashes, Maples, Norway Spruce and Austrian and Corsican Pines. He recommends a protecting belt of trees to be planted on the northern side of every farm. The proper proportion of forest for Massachusetts he considers to be 25 per cent. Besides the woodlands in the State, there are nearly two millions of acres of unimproved lands, 1,200,000 acres of which is admirably suited for forest growth, the value of the timber on which, in fifty years, could only be reckoned by hundreds of millions. True, this would devote half the State to Sylviculture; yet, he thinks it would be its most profitable use, and be a benefit to that and other States.

Professor Sargent expresses his concern at the rapid destruction of timber in the United States, as sure to enhance its price, and produce many agricultural evils. He says, "Every year the destruction of the American forests threaten us with new dangers. Every year renders it more imperative to provide some measures to check the evils which our predecessors in their ignorance have left us as a legacy, with which to begin the second century of our Republic."

The Professor calculates so large a timber profit to his State, besides other advantages as to make it a moral duty, and patriotic achievement, to engage in tree planting, and insists that railroad corporations must plant in their own interest.

If farmers would generally plant one side the highways, and a row or belt of sheltering trees on the north side of their farms, and they and the Governments should see that all untillable grounds should be kept in the growth of timber as far as practicable, exempt from plunder and fires, we should attain that proportion of trees over the whole country which is required by the best interests of agriculture and the general good of the people. This should be the aim of all.

In Pennsylvania we have begun no considerable tree planting, except it be that in Fairmount Park. There, besides previous plantings, the Commissioners have planted within eighteen months, 12,082 trees, of the value of $14,490; and have yet in the Nursery 33,304 trees.

From the reserved moiety of the Michaux income, the American Philosophical Society has established in the Park the course of Lectures delivered by Dr. Rothrock on Arboriculture and Botany, who dwells emphatically upon the importance of woods for the preservation of water and soil and in protection of agriculture.

Citizens of Pennsylvania have, however, commenced an important Sylviculture in Eastern Virginia. Landreth & Co., of Philadelphia, have for six years and a half been planting 300 acres of black walnuts, and in a few years will complete some thousand acres in hard wood nut bearing trees. Mr. Burnet Landreth, a member of the firm, without fear of inciting rivalry, and without any apprehension that the growing market for timber can be overstocked, has published their doings in the *Journal of Forestry*, published in London. He seems actuated by the spirit of patriotism more than the love of profit. He laments that the White Pines of our State have

gone, and those further north-west are rapidly going, leaving no succession in kind, and the Oaks and Hemlocks are fast departing, which are sometimes cut down to get the bark for the tanner, with but the contingent chance of selling the wood for cross ties and lumber. When felled both objects should certainly be secured.

Landreth & Co., buy worn-out lands cheaply ; buy them near navigable waters, for cheap transportation by water, sow or plant nuts of chestnut, walnut and hickory, or sow the seeds of the white pine, which they find to grow in the South, and leave the yellow pine seeds to sow themselves. They see a boundless area of timber growth before them and others ; trees of slow return ; but know that the market will await its maturity, and will be ever a rising one, as the country shall become more shorn of timber, denser in population, and more demand the consumption of timber. The profit awaited will be surely compensatory for capital, labor and interest thus invested ; and though for many years unproductive of annual income, the timber crop when it matures will be found to cover all the investment, with no interest of capital expended, but there self-invested by ligneous increment. It is an inheritance laid up for heirs ; a good to them ; a good to the nation. Yet the harvest is not all postponed, and to be but once, at distant period ; for the process may be one of successive thinnings of small trees thickly planted, and of old trees of different kinds maturing at different times, thus bringing repetitions of profits. The sowings of nature and the plantings of man may also be in every successive year, and different tracts thus yield annual returns as trees are fit to cut. The plantings should be annually repeated as the woods shall be thinned. It should be a rule, except in needed thinnings, never to cut down thrifty trees that are yet rapidly making wood. An economical instinct will teach all this to the provident forest proprietor. As certainly as the axe and portable saw mills cut up the best timber of the forest, as they surely are rapidly doing, the plantings of man, and the protected growths of nature, should follow with equal pace, with selections of kinds most profitable, except where cleared land is fit and required for agriculture. The whole country has but its 25 per cent., while there are excessive quantities in large tracts in some sections, and no forests in other vast areas. This shows another distribution of trees must be a work of the future.

Philadelphia should not overlook the interest she has in keeping well wooded the sources of the Schuylkill, the river that gives her chief supply of water. The Schuylkill Navigation Company began this beneficent work of supply of water and wooded protection by building their magnificent mountain reservoirs, and buying wooded tracts, by the shade of trees to protect the springs that supply them.

It will also be to the interest of the city to build, in the future, more mountain reservoirs, and protect their supply of trees, that she may have adequate stores of waters, there to meet the exigency of summer drouths, when her population shall have increased. The secured wooded water sheds, and the plantings in progress in Fairmount Park subserve the same

purpose ; but with the city's growth her needs will increase of conserving her water supply at a distance, that our second beautiful river may continue adequate to the wants of a metropolis of millions.

Here should be specially brought to notice, the necessity of a vast amount of tree planting in the prairies and plains that extend over the central length and breadth of our northern continent. With great depths of alluvial soil, protected by the heavy prairie grasses, which through the centuries have annually added their decaying richness to the vegetable mould, the rolling or flat prairie regions have but occasional groups of trees. The cause of the absence of trees seems to have been the frequent fires that swept over the prairies, for wherever protected by the settlers from fire a thick and flourishing growth of trees springs up, and the plantings also thrive.

The prairies need trees the more, to induce precipitation of rain, and to protect the soil, springs and streams from evaporation, by reason of the immense extent of wheat and corn crops now grown in continuous fields of a thousand or more acres, each spring sown or planted, thus exposing the bare ground for more than half the year, in the intervals of the crops, to the drying sun, to be swept away alike by winds and rains. And heavy belts of growing timber are wanted for more than the attraction and retention of rain and water ; are wanted to make it something more possible to arrest the great prairie fires ; and also, to break the force of the storms and tornadoes that so destructively sweep the central parts of our continent ; where no sheltering mountains or hills exist to arrest the force, and disperse the winds. Some such benefit has already been perceived and acknowledged.

In the prairie and treeless regions of the central West, where settled, the settlers have perceived it to be their interest to plant, and to save the spontaneous growths of trees, and beyond the incentive of interest, the pleasurable occupation has kindled an enthusiasm for Arboriculture. The fires are fought, and less frequently lighted ; coal, when at hand, is preferably used for fuel, and the spontaneous second growth is generally better than the original forests where these had been. In the State of Minnesota, Martin County, "thousands of acres of young timber trees are growing, some spontaneous, others planted ;" in Redwood, "The cultivation of forests on the prairies will amount to from 1 to 20 acres per quarter section ;" in Steele County, "Some attention has been given to planting forest trees, and the interest is on the increase, as the experiments have been quite successful ; many small groves of quick growing varieties being planted near dwellings ;" in Watonwan, 1,000 acres are under cultivation, in groves of from one to 12 acres ; in Nobles County, "An association has been organized, and the children in each school are being organized into Centennial bands of little foresters, with promises of badges and more valuable prizes for planting trees." In the State of Iowa, Crawford County, "Large numbers of the more thrifty farmers have planted groves of maples, cotton wood, black walnut and box elder, which have grown

with great rapidity, and the vast expanse of treeless prairies, which a few years ago stretched in every direction as far as the eye could see, is now dotted over with beautiful groves, which greatly add to the wealth of the county," and in Cherokee County it is reported, "A great many are planting timber, which grows fast." For Missouri it is reported that, "In the portions of the State that were originally prairie land or openings, spontaneous and thrifty forests have sprung up and increased, as increasing settlements have prevented annual prairie fires;" for the County of Greene it is stated, "Nearly all the old timber is inferior, for the reason that the woodlands produce abundant grass, which is burned over every season, and injures the trunks of the trees. Forests, from which the fires are kept are very thrifty, many of the trees adding one inch to their diameter annually." See Agl. Rep. for 1875.

For Kansas and Nebraska, the Report of 1875, says, "On original prairies, forest growth is increasing rapidly from two causes: The first is, the arrest of prairie fires by cultivation, which has resulted extensively in the spontaneous springing up on uncultivated portions of a thick growth of young trees, which grow with wonderful thrift; the second cause being the planting of forests, now doubly stimulated by legislative encouragement, and by assured success in respect to both growth and profit. In addition to personal advantages to the planter, in the increased comfort, beauty, and money value of his premises, it is claimed that a public benefit is already perceptible in a modification of the climate, particularly in the way of assuaging the severity of the once unimpeded winds." Of Jefferson County, Kansas, it is said, "The forest area is rapidly increasing in consequence of stopping the prairie fires, and the planting of new groves;" while of Barton County, it is said, "Flattering results have been obtained from planting tree seeds and cuttings."

Tree planting in California is receiving much attention. Before the 1st January, 1876, James T. Stratton had planted in Alameda County, 195 acres with 130,000 Eucalyptus trees, that is the Blue Gum of Australia, eight feet apart each way. The company owning the railroad between Los Angelos and Anahelm, in Southern California, had planted 140 acres, with about 80,000 Eucalyptus trees. In the spring of this year it was announced that, "The Central Pacific Railroad Company has lately arranged to have 40,000 *Eucalyptus Globulus* trees set along the 500 miles of the right of way of the company. This is only the first installment, as it will require about 800,000 of the trees for the 500 miles of valley where they are to be cultivated. The immediate object of the plan is to increase the humidity of the region, and lesson the liability to droughts."

The United States Government has begun to take a deep interest in the subject of the preservation of American Forests. This appears to have had inception in a Memorial to Congress of the American Association for the Advancement of Science, upon the cultivation of timber and the preservation of forests, in August 1873, signed by Franklin B. Hough and George B. Emerson their Committee, which being referred to the Com-

mittee of the House on Public Lands, Dr. Hough, on March 10th, 1874, submitted to Washington Townsend, Chairman of that Committee, his views at length on the subject of the Memorial. These were printed by order of the House, in a Report of 118 pages. It is a full, yet compact statement of many facts and statistics, which abundantly sustain the conclusions herein expressed. There followed in October 1875, the Report of the Commissioner of Agriculture for that year, a division under the head "Statistics of Forestry," from p. 244 to 358, giving the forest area of every county in every State in the Union, in number of acres, and the percentage of the whole number in the County and State, with other valuable information. It is very important in its promise of future reports, and also from the fact that will be the basis of contrast, to show the progress of reforesting the country. An Act of Congress of August 15th, 1876, gives earnest that Congress will guard this great national interest, especially as it made an appropriation for the compensation of a competent commissioner to investigate and report upon the preservation of the forests, and the exportation of timber and other products of the forests. I have an answer to my inquiry, from Dr. Hough, the Commissioner, saying that he is at Washington to print his report in that of the Commissioner of Agriculture; that he has tried to do justice to Michaux and others; thinks the facts he has collected opportune, and that the interest in forestry is growing. The President's Message to Congress of this month earnestly recommends legislation to protect the timber belonging to the Government, and the preservation of the forests of our country.

The proposition before us invokes physical causes for physical effects. Yet are these very interesting to our mind and feelings. They concern deeply human life and happiness. The mind must plan and execute the work; must appreciate the beneficent results, and not without gratified emotions in view of the good to come. The purposed means will seek to influence the elements; in a measure to rule the powers of the air; to draw rains from the clouds; to detain the waters in the earth to flush the springs and swell the streams; will both drain the marshes, and cause wells and fountains to flow in the desert; cause the grasses and cereals to cover the fields, and the forests and woods and trees to grow on mountains, hills and plains. Yet all this, is not to speak or act presumptuously, for it is but to use the powers placed at man's disposal. It is to do more extensively what has been done; what is therefore practicable. Man is to engineer, to plow and plant, and sow and water, but God must give the increase. Man is to obey the first command, "Replenish the earth and subdue it." Obedient to this we have the promise, "I will give you rain in due season, and the land shall yield her increase, and the trees of the field shall yield their fruit."

That the evils reviewed have been terribly aggravated during many centuries, should not discourage us. The full remedy may require as many centuries as the cause has been operative; but every step of repair is beneficent progress. The world is now fuller of resources than ever before. Man's enginery is gigantic; his machinery is imbued with intelligence.

He can destroy faster ; but knows how to repair his injuries sooner. But to cease to do evil is to begin to do good ; for Nature only asks man's leave to renew her beneficent growths. Stop the fires on the prairies, lighted by the hunter for unknown centuries, and Nature will clothe them with forests. Plant with trees, and protect the self sown seeds of the forests along the waste lands of the seaboard, and they are born who may see them all reforested ; see them also renew a virgin forest soil. We have just begun many beginnings. Let them be followed up by many zealous co-operators, and our country will exhibit a prosperity, salubrity, and beauty never before seen, and in due time will become the dwelling-place of millions more human souls, else not to be born ; souls to be happy on earth, and to people heaven. If this world was worth the making it must be man's duty to make it teem with happy life.

ADDENDA.—Since reading the above paper, Prof. Lesley has kindly sent me two quotations which strongly support the views and purposes of the essay read. E. K. P.

I. "The country from the head of St. Croix river [in Wisconsin] to Bayfield is covered with drift. . . . not an outcrop for fifty miles. Most of the district is destitute of living springs and streams. Numerous depressions in the drift are partly filled with water . . . . . The soil is sandy and barren, supporting only a stunted growth of 'jack' pines and 'scrub oaks.' Fire has killed the timber over wide areas, on which grass was growing, exhibiting before our eyes nature's simple method of converting woodland into prairie. The reverse process is just as simple. When prairies are no longer swept over by fire, timber springs up, re-converting prairie into woodland. Grass, with fire as an ally, can beat timber. Timber can beat grass when it has no fire to fight."—Report of O. W Wight in Geology of Wisconsin, p. 76, 1877.

II. "In the whole Kingdom of King Devánámpriya Priyadarsín, as also in the adjacent countries ; . . . . the Kingdom of Antiochus, the Grecian King and his neighbor Kings, the system of caring for the sick, both men and cattle, followed by King D. P. has been everywhere brought into practice. Wherever useful healing herbs for man and beast failed, these he introduced and cultivated. Wherever roots and fruits were wanting, these he introduced and cultivated. He caused also wells to be dug and trees to be planted on the roads for the benefit of cattle."—Dr. Kern's translation of the Girnár rock inscription in India, second section of the tablet. See p. 193 and Plate 1. Jour. R. Asiat. S. Vol. IX. part 2. July, 1877.

What Christian nation has provided so humanely for traveling man and beast? The purpose of trees and shade as above advocated is immediately practicable and beneficent. Let us also open the roadside springs and wells, and furnish the cup for cold water ; and maintain the supply of medicinal herbs, roots and barks. This we will begin in the Park as soon as the Pharmaceutists will lend their efficient co-operation. Except in the hospitals of our large cities, and county poorhouses, the sick wayfarer must depend upon humane tavern landlords and benevolent citizens, who seldom fail in Christian charity. But may God and man save us from *Tramps*.

Causes of the Huron Disaster.

By Prof. Wm. Blasius.

(*Read before the American Philosophical Society, December 7, 1877.*)

The whole country mourns for the appalling and terrible disaster that befel the United States war-vessel "Huron" with her hundred brave mariners in the recent storm on our coast. It is not the rareness of such terrible calamities that causes this surprising and deeply felt sympathy with the brave and gallant men who found here so unexpectedly and untimely their watery grave. The Public Ledger of Philadelphia, only a short time ago enumerated 44 vessels belonging to, or bound to, or from American ports only that shared during the short period of one single month a similar fate. Unfortunately such calamities are not seldom on our shore, and they indeed follow each other so rapidly in succession that the last one only obliterates the still vivid traces of the preceding one. Thus they are forgotten one by one, and their stories are only revived for moments, when commerce and pleasure seekers apply to the Government for the removal of the wrecks that are in the way of their pursuits.

What makes, however, this case so particularly impressive in the minds of all men is, that the Huron was a war-vessel, recently built, supposed to be well fitted and found, staunch and speedy, that it was commanded by naval officers who are looked upon as particularly skilled navigators, and understand how to fight the storm as well as the foe, and to whom the nature of the depth in these friendly waters ought to have been as familiar as their state-rooms. We cannot wonder then that the public anxiously inquires into this dreadful and mysterious disaster, and tries to unravel its cause.

Neither is it strange in these corrupt conditions of society that some find it in the defective construction of the vessel; some lay the blame on the commander for having started at sea when the warning signals were flying, and for hugging the coast too closely in order to gain time. Some wise old captains of merchantmen lament the loss of good old practical seamanship; they hint "that the naval officer proper need now be but an indifferent kind of a sailor, so long as he is a good mathematician, chemist or drill-master, appears well, dresses tastefully in well-fitting uniform according to the latest edicts of the naval Turveydrops, and has possessed himself of a diploma issued by the United States Naval Academy." There may be some truth in these suggestions, but it is not likely.

From the meagre facts hitherto published, it will of course be useless to argue any of these surmises; but as the Government doubtless will probe this matter to the bottom for the sake of preventing future similar accidents, I would respectfully draw its attention to a third potent agent which seems to have been completely overlooked by these wise critics, and which probably had more to do with this fearful disaster than the strength of the vessel or the lack of so called seamanship, and this third

agent is the general and lamentable want of a knowledge of the true nature of a storm.

The statements made to the reporter of the New York Herald by Rear Admiral Trenchard, commanding the North Atlantic Station, on board the flagship Powhatan, lying off Fortress Monroe, seems to throw the first two supposed causes almost out of the question. He says: "That on Thursday the vessel was thoroughly inspected by him and his staff, and found to be in first-class order," as only would be expected from a first-class lately built war-vessel. "Captain Ryan," he says, "was a careful and experienced seaman, had surveyed the coast along which he was to pass, and was considered one of the best navigators in the service;" this settles, it seems to me, these two points above all suspicion.

As to the third agent, the storm, which by the general critic has been overlooked, but which the Admiral takes also into consideration, he says: "He sailed at eleven o'clock in the morning, at which time the barometer was not indicating bad weather; was rather above, as shown by the official log." And the surviving officer, Master W. P. Conway, gives us the following information: "At 8 P. M. there was a strong gale blowing, and the sea was running very high. The barometer stood at 30.04 for three hours. The jib-stay was carried away soon after 6 P. M."

The last statements of Admiral Trenchard and Master Conway have reference to the storm and the theories about it, and furnish the key to unravel the cause of this mysterious and sad tragedy. The barometer, the only guide science hitherto has furnished the navigator for his safety was conscientiously consulted; it stood "rather above" the mean, and therefore "did not indicate bad weather."

Captain Ryan, who unfortunately cannot speak any more for his own justification, but who was considered "one of the best navigators in the service, and a careful and experienced seaman," had undoubtedly looked also to this same guide for advice before he started, and finding of course the same answer, was certainly justified in view of the present state of science and good seamanship to start on his voyage in spite of the warning signals flying, the more so as according to the papers these signals had been flying for weeks uselessly and had become, therefore, disregarded generally by seamen. From his high position and reputation, and the testimony Admiral Trenchard bears him, we can neither doubt for one moment that he was fully acquainted with the science of storms and the rules of navigation based on it, and that he had studied the writings of Capper, Thom, Piddington, Reid, Redfield, Dove and others whose views are adopted officially in all navies. The accusation of bad seamanship seems, therefore, unfounded, unjust and cruel, because all these celebrated men of science up to the present time teach, that the storm consists in an area of low pressure, *i. e.*, an area where the barometer stands below 30 inches, and that the navigator, therefore, has to expect a storm or a so called cyclone only when the barometer falls below this mean, but when the barometer stands above he may look for fine and clear weather from the approach of an area

of high barometer or an anti-cyclone. Captain Ryan was, therefore, justified in starting to sea in accordance with the present navigation rules deduced from the generally accepted theory.

In my work, "Storms, their Nature, Classification and Laws" (published two years ago), I think I have demonstrated that this old theory is wrong and worse than useless, that it is illusive and mischievous, and leads often into danger instead of out of it. I showed that the area of low pressure or low barometer is not the storm, but only the effect of the storm, and that the progressive storms (the equatorial and polar storms) of the temperate zone, with which we have principally to deal, consist of two areas of high barometer or rather of two ærial currents of different direction and temperature, which, so to speak, create the area of low barometer between them, by the obliquely upward flowing of the warmer current over the face of the colder. Whether the storm, *i. e.*, this system of two opposing currents of different temperature which displace each other, comes over us with falling or rising barometer depends entirely upon the kind of storm, the state of its development and the position we are in towards these three parts of the storm, facts about which the clouds and the direction of the wind give trustworthy information. The barometer is, therefore, unreliable.

To illustrate this important matter I showed that the heaviest rains and most destructive storms had passed for two days during their earlier development in the form of high pressure through the jurisdiction of the Signal Service Bureau without being recognized as storms, until arriving at the coast—as for instance, the Nova Scotia storm, 1873—they destroyed over a thousand vessels and six hundred lives in almost a single night.

The fact that the barometer stood above the mean height is, therefore, an explanation of why the Huron sailed notwithstanding the Signal Service warnings, but why should she hug the coast? In the absence of the commander the most that can be offered is a plausible conjecture, but it seems probable that his action in this respect was in the belief that this was the safest course for him to take, a belief founded on the rules issued by the Navy Department for maneuvering in such cases.

These "Nautical Rules" instruct the navigator that in storms or cyclones the "manageable semicircle" is on the left side of the path of the centre, *i. e.*, in storms traveling up the Atlantic coast the "manageable semicircle" is on the coast side of the storm, and the "dangerous semicircle" out at sea. And therefore, according to these rules issued for his instruction and guidance, Commander Ryan did perfectly right to keep to the coast so as to be in the "manageable semicircle" of the cyclone. He had to select between two evils—the "dangerous semicircle" and the coast. Had he gone out to sea he would have come in the "dangerous semicircle" and disobeyed these published rules of his department, although as the sequel shows he would have saved himself, crew and ship. These "Nautical Rules" are founded on the dicta of the most eminent meteorological authorities, and strictly in accordance with the science as it now stands, but

when several years ago I asked the accomplished Chief of the Hydrographic Office, Bureau of Navigation, how many vessels he supposed they had saved, he responded: "Not many, I think." It gives me pleasure to state that the same gentleman has lately recommended my work for use in the Navy, saying, "that his experience bears it out."

The fate of the Huron is but another of the many victims to the Moloch of erroneous meteorological theory; it is too much to hope that it will be the last one, but let us trust that such terrible events will grow less and less frequent until the time comes when there may be none fairly chargeable to a lack of a knowledge of the true nature of storms.

Bituminous Material from Pulaski County, Virginia, U. S.

By Dr. Charles M. Cresson.

(*Read before the American Philosophical Society, October* 19, 1877.)

The locality from which the sample was taken, is four and a half miles north of the Atlantic, Mississippi and Ohio Railroad property of W. T. Hart, said to be from a vein averaging 32 feet in thickness. Dip variable from 30° to 50°; is covered by 2 feet of fire clay. Footwall, soft gray slate. Sample from 45 feet below water level.

Results of laboratory examination as follows:

Color	Black.
Streak	Brown.
Structure	Lamellar and Friable.
Specific Gravity	1.566.
Moisture and Volatile Matter	7.50 per cent.
Fixed Carbon	65.52 "
Ash	26.98 "

There was no clinker got in the laboratory experiments, although the ash was subjected to a high degree of heat.

Sulphur.....0.165 per cent.

One pound of material burned in Oxygen evaporated 10.12 pounds of water from 212° Fahrenheit.

After deducting the average losses, by heat absorbed by ash, products of combustion and radiation, there remains as the result of the combustion of one pound of fuel, 7.59 pounds of water evaporated, or about the same amount as is evaporated by burning one pound of the best coke from bituminous coals.

Experimental trials made in locomotive and stationary tubular boilers, with samples supposed to represent an average of the vein, produced somewhat different results from those obtained from the selected samples sent to the Laboratory for analysis. Upon the large scale, this fuel gave at first an exceeding hot and lively fire, but as soon as the bituminous matter was burned off, the fire became dull and required stirring. When the draft was insufficient to carry off the ash, there was gradually formed a spongy, lava-

like cinder, which it was necessary to remove in order to obtain sufficient draft. It therefore appears, that although samples of this fuel can be selected which will give favorable results upon the small scale, the mass of the vein can hardly be used for the general purposes to which anthracite is applicable, and that it requires some especial device for the removal of the voluminous ash, to enable the successful and continuous use of the fuel for ordinary purposes.

CONTRIBUTIONS FROM THE LABORATORY OF THE UNIVERSITY OF PENNSYLVANIA.

No. XII.

A new method for the Decomposition of Chromic Iron. By Edgar F. Smith, Ph. D., Assistant in Analytical Chemistry, University of Pennsylvania.

(*Read before the American Philosophical Society, December* 21, 1877.)

Recently I was led to try the action of bromine and sodium hydrate upon pulverized chromic iron, and as the amount of chromium extracted in this manner was rather surprising, the following experiments were made, to ascertain what effect bromine alone in presence of water would have upon the same substance.

I. Moderately fine chromic iron (.1500 Grm.) was placed in a tube of hard glass, and after adding dilute bromine water and sealing the tube, the latter was placed in an air-bath and heated for twelve hours at a temperature of about 130° C.; when cool the tube was opened and its contents poured upon a filter. The insoluble residue was thoroughly washed by decantation, and upon the filter, with hot water. The filtrate after concentration was treated with a slight excess of ammonium hydrate, causing the precipitation of aluminum hydrate, &c. The latter was filtered off and the yellow colored filtrate, then warmed with hydrogen sulphide to reduce the chromic acid to oxide. The precipitate formed, after protracted digestion, was allowed to settle and the clear liquid filtered. After washing the precipitate it was dissolved in a few drops of dilute hydrochloric acid and re-precipitated. This operation was repeated and the precipitate finally transferred to a filter washed, dried and ignited. The amount of chromium oxide found corresponded to 15.50 per cent, of the substance taken.

The amount of chromium remaining in the material not attacked by the bromine was not estimated.

II. .2000 grms, substance, as finely pulverized as could be obtained by grinding the material in an agate mortar, were heated in a sealed tube with water saturated with bromine and a few drops of bromine. The tube was allowed to remain in the oven for four days, the temperature ranging from 175° – 190° C. Upon opening the tube its contents were poured into a

beaker and evaporated ; water then added and the solution filtered. The residual, unattacked mineral powder after washing, drying and igniting, weighed .0820 grms. The filtrate from this was treated precisely as in (I) and the chromium oxide obtained from it amounted to 28.05 per cent.

III. In this experiment only .1500 grms. substance were employed. The material was of the same fineness as in (II). Instead of using dilute bromine water as heretofore, an excess of bromine was poured over the substance and but a very small quantity of water added. For three days the tube was exposed to a temperature varying from 150° – 175° C. At the expiration of this time the tube was examined, and as the substance appeared to be perfectly decomposed, the solution was removed from the tube and evaporated in a beaker glass to expel the large excess of bromine, upon the gradually disappearance of which a dark powder showed itself. The solution was strongly diluted with water and filtered. The insoluble residue was thoroughly washed with hot water. Dried and ignited, this weighed .0140 grms.

The filtrate was mixed with an excess of ammonium hydrate and evaporated almost to dryness in a casserole. The solution was then diluted with water and filtered from the aluminum hydrate, &c., and treated as in (I). The percentage of chromium oxide extracted equaled 49.60 per cent.

IV. From the preceding experiments it appeared very evident, that all that was lacking to render the decomposition complete was to have the chromic iron in an exceedingly fine condition. To this end the material that had been ground to an impalpable powder in an agate mortar was elutriated, then dried, and two separate portions of .1500 grms. each placed in good, hard glass tubes. To each portion was added a rather large quantity of bromine water and from 10–12 drops of bromine. Both tubes were heated for one day at 130° C. For two successive days the temperature was maintained at 170° C. At the expiration of the third day, one of the tubes was removed from the oven and opened. Red oxide of iron had separated and undecomposed material was no longer visible. The whole was poured into a beaker and evaporated ; water added and filtered. The residue was thoroughly washed, dried and ignited, then transferred to a beaker glass and heated with dilute hydrochloric acid. The entire mass dissolved readily and without a residue. The decomposition was, therefore, complete.

The filtrate from the ferric oxide was evaporated almost to dryness after the addition of an excess of ammonium hydrate, then diluted and filtered. The solution was reduced with hydrogen sulphide and the precipitate, after filtering and washing, dissolved in dilute hydrochloric acid and re-precipitated with ammonium hydrate. This operation was repeated and the chromium oxide obtained was 62.66%.

The second tube which was removed not long after the first, contained a large amount of separated ferric oxide. This, after filtering off the chromium solution, also dissolved very readily in warm, dilute hydrochloric acid, leaving not the least trace of residue.

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The filtrate from this, after being similarly treated as above, yielded 62.83 per cent. chromium oxide.

These results accord with those of Garrett, who analyzed the same ore from Texas, Pa., and obtained about 63. per cent. of chromium oxide.

The ferric oxide that separates out in the tube during the decomposition will not contain any chromium whatever, if it is thoroughly washed with boiling water.

In no instance was iron found in the solution containing the chromic acid.

Several tubes containing the pulverized substance, potassium hydrate and bromine water, were heated at 125° C., but invariably exploded before the decomposition was completed, and therefore no further attempts were made to use the alkali to aid in the decomposition.

All that is necessary to effect the complete decomposition of chromic iron by this method is that the substance be exceedingly fine, and that the same be exposed with bromine water to a temperature of 180° C., from two to three days. The addition of 10-12 drops of bromine hastens the decomposition very decidedly.

In connection with the above, it may be well to mention that the insoluble chromium oxide obtained by the ignition of the corresponding hydrate, may be brought into solution again by digesting it together with bromine and sodium hydrate in a beaker.

Precipitation of Copper with Sodium Carbonate.

The precipitation of copper from its solutions by sodium hydrate, gives a precipitate that is worked with difficulty. Sodium carbonate, on the other hand, added to similar solutions, and these boiled, affords a dark brown, granular precipitate, that may be readily and completely washed with hot water.

Mr. Harry G. McCarter, student in the Laboratory of the University, made the following analyses, which show that the method yields as accurate results as could be desired.

I. .2000 grms. $CuSO_4 + 5H_2O$—dissolved in water and precipitated with sodium carbonate, gave .0630 grm., CuO = 25.15 per cent Cu.

II. .2000 grms. $CuSO_4 + 5H_2O$—treated as above, gave .0634 grm. CuO = 25.30 per cent Cu.

The theoretical percentage of copper in the salt is 25.25 per cent.

After the addition of sodium carbonate in slight excess to the copper salt solution, the latter was boiled for an hour, until all the carbon dioxide was expelled.

The filtrates from the precipitates in every instance were evaporated, but not the slightest trace of copper discovered.

An excess of acid in the solution from which it is desired to precipitate copper by an alkaline carbonate, should be avoided.

The presence of rather large quantities of alkaline nitrates or sulphates will cause the solution of the precipitates first produced by the carbonates. Continued boiling will not remedy the matter. From such solutions, however, the alkaline hydrates will not fail to precipitate the copper.

Descriptions of New Vertebrata from the Upper Tertiary Formations of the West.

By E. D. Cope.

(*Read before the American Philosophical Society, December* 21, 1877.)

PITHECISTES BREVIFACIES gen. et spec. nov.

Char. gen. These are chiefly known from a mandible which supports the dentition of one side and part of the other. The dental formula is I. 1 ; C. 1 ; Pm. 3 ; M. 3. The single incisor of each side is weak and easily lost, and there is on one side only, a small alveolus for a minute second incisor. It is therefore probable that in some individuals the incisive formula is 2. The canine is not large, and closes in front of the superior canine in the usual manner. The first and second premolars are one-rooted, and their crowns are wider than long. That of the third premolar is robust, but longer. The molars increase rapidly in size, and are not prismatic, but are well rooted. They are worn in the specimen, but their structure is probably shallow selenodont. The last molar has a long heel or fifth lobe.

Char. specif. The mandibular ramus is very deep posteriorly, and the incisive border is not prominent. The canine tooth is quite small, its transverse diameter being less than that of the first premolar, and equaling it antero-posteriorly. The exterior incisor is weak, and the crown expanded transversely, and obtuse. The crown of the first premolar is worn deeply by the superior canine. The transverse diameter at the base of the crown exceeds the antero-posterior. The crown of the second is wider than long, and of the third longer than wide. The molars increase rapidly in size posteriorly, so that the length of the third equals that of the three premolars plus the canine. The heel is long, and is connected with the remainder of the crown by a narrow plate, or in section, an isthmus. There are no cingula, but an accumulation at the bases of some of the teeth resembles the deposit of "tartar." The symplysis is very robust, and its upper surface is marked on each side by a low longitudinal swelling. The opposite premolar series are slightly convergent.

The form of the mandible of this animal, as well as the number and proportions of the teeth, curiously resemble that of the corresponding part of a monkey. The species was about the size of a red fox.

Measurements.	M.
Length of ramus from heel of molar III	.057
" molar series	.048
" premolar series	.015
" second true molar	.010
Width " "	.007
Length of last molar	.018
Width of " at front	.007
Length of symphysis in front	.020
Depth of ramus at first premolar	.017
" " second true molar	.025

BRACHYMERYX FELICEPS gen. et sp. nov.

Char. gen. These are derived from the superior dental series. These are I.^{2}; C.^{1}; Pm.^{3}; M.^{3}. The true molars have the bases of the crowns little swollen, and the last two of the superior series are but shortly rooted; the anterior ones have longer roots. The true molars are simply selenodont, with the anterior extremities of the external crescents forming prominent ribs. The last superior premolar consists of two columns posteriorly and a single trenchant one anteriorly, and the second (first of the series,) is simple and trenchant. The worn posterior face of the canine shows that the first inferior premolar is the functional canine as in *Oreodon*. There is a very slight diastema in front of or behind the canine, the series being continuous, as in *Oreodon*.

This genus differs from *Pithecistes* in its canine like first inferior premolar, and in the trenchant character of the anterior premolars. With *Cyclopidius* it enters the family group of the *Oreodontidæ*, but approaches the suilline types still more nearly in its probably coössified symphysis mandibuli.

Char. specif. This ungulate was a little smaller than the species last described, and is represented in my collections by two nearly complete crania without mandibles. The head is depressed and the zygomata widely expanded; the palate is wide, and the muzzle short. The infraorbital foramen is double and issues above the adjacent parts of the second and third (last) premolars. Immediately in front of it the side of the face is concave.

The projecting anterior angles of the external crescents of the molars are very prominent, forming strong vertical ribs. The external border of the last premolar is only interrupted by a little convexity. The anterior narrow portion of the second premolar is incurved. This tooth is two-rooted; the first is one-rooted. The canine is small and strongly recurved. It is cylindric at the base, but beyond this is narrowed antero-posteriorly partially from the friction of the first inferior premolar. The anterior face is regularly convex. The first premolar has a very slight internal basal cingulum; its cutting edge is directed obliquely to the long axis of the cranium. There are no cingula on the other teeth. The enamel of the true molars is smooth on the external side of the crown. There is no enamel on the inner walls of the central lakes.

Measurements.	M.
Length of dental series to anterior border of canine	.050
" premolar series	.017
" last true molar	.012
Width of " "	.006
Length of first true molar	.007
Width of " "	.006
Length of first premolar	.006
Width of " "	.006
Length of canine tooth	.009

Measurements.	M.
Diameter of canine tooth (transverse)	.004
Width of cranium between first premolars	.016
" " " last molars	.030

The cranium of this species is about the size of that of a large domestic cat.

CYCLOPIDIUS SIMUS. Gen. et. sp. nov.

Char. gen. Dental formula I. $\frac{3}{3}$; C. $\frac{1}{1}$; Pm. $\frac{4}{4}$; M. $\frac{3}{3}$. The superior canine is small and is separated from the first premolar by a very short diastema. First premolar simple, trenchant; second premolar two rooted, with one principal cutting edge; third with an external crescent and a rudimental internal one, not united in front. Fourth premolar with the inner and outer crescents only, and these well developed. Last true molar without heel. Inferior canine with much wider crown than the incisors with which it is in close association. First premolar canine-like, but not very large; second premolar simple. Third and fourth premolar with the anterior portions trenchant, the posterior with wide or double columns. Last true molar with large fifth crescent or column. True molars of both jaws prismatic. Symphysis mandibuli coössified.

Frontal bones much abbreviated in front by a large upwards-looking fossa on each side, which are separated by the very narrow and short nasal bones. There are lachrymal fossæ and a huge foramen in front of them, which communicate with the maxillary sinus. There is a prominent transverse supraoccipital crest, and the otic bullæ are greatly inflated.

This genus is related to *Leptauchenia*, Leidy, but differs in having but two lower incisors below. That genus belongs to a lower horizon, the miocene of White River, while the present form is its successor in the upper Miocene or Loup Fork beds. The remarkable character of the vacuities in the superior region of the front part of the cranium, reminds one of the existing genus *Saiga*. Dr. Leidy partially described a similar structure in *Leptauchenia*. In this genus what are clearly nasal bones in *Cyclopidius*, he terms frontals, probably by error.

Char. Specif. This animal is rather larger than either of those above described, and is represented in my collection by one nearly complete cranium, one entire left maxillary bone, and the under jaws of five, and probably of several other individuals.

The skull is wide and abbreviated in front. The maxillary bones are everted on each side of the external nares. The malar bone is very wide or deep, and sends upwards a strong postorbital process, which is broken off in part, but which probably completed the orbit. The superior facial fossæ reach backwards nearly as far as the middle of the orbit. They are longitudinal narrow ovals, open in front. The projecting supraorbital portions of the frontal bone with the nasals have a tripodal form. The lachrymal fossa looks outwards, upwards and forwards, and the large maxillary foramen outwards. The infraorbital foramen is double, and issues above the contiguous portions of the third and fourth premolars.

The external crescents of the true molars present prominent anterior angles, which form strong vertical ribs. The first superior premolar has a weak, and the second premolar a very strong internal basal cingulum; there are no other cingula. The diastema is as wide as the diameter of the canine.

The first inferior premolar is one-rooted, and the second two-rooted, and both are longer than wide in horizontal diameter. The middle pairs of incisors are very small: the external one on each side is much larger, the diameter equaling half that of the canines. The first and second true molars are subequal, and are together longer than the third, which does not quite equal in length the three premolars. The heel of the last molar is not so long anteroposteriorly as each of the other columns. The symphysis is steep, but is everted at the incisive region.

Measurements.	M.
Length of ramus from heel of m. III	.065
" of molar series	.036
" of premolar series	.016
" of second true molar	.011
Width of " " "	.006
Length of third " "	.016
Width of " at front	.006
Length of symphysis in front	.025
Depth of ramus at first premolar	.022
" " second true molar	.025
Width between superior anterior premolars	.014

CYCLOPIDIUS HETERODON sp. nov.

This species is represented by a portion of the right maxillary bone, which supports the last premolar, first true molar, and portions of other teeth. It is a smaller form than the *B. simus*, and differs in several important respects. The infraorbital foramen is single and larger than those of the other species. The fourth premolar, while of the same constitution as that of *M. simus*, is relatively much smaller, not equalling in the extent of its grinding face one column of the first true molar. The latter is prismatic, and of usual form. Its external crescents are not produced as in *B. simus*, so that there are no distinct vertical ribs.

Measurements.		M.
Diameter of last premolar	anteroposterior	.0050
	transverse	.0045
Diameter of first true molar	anteroposterior	.0080
	transverse	.0055

This species was found with the three preceding in the Upper Miocene of Montana by my assistant, J. C. Isaac.

BLASTOMERYX BOREALIS sp. nov.

This genus was defined by me in the fourth volume of the Report of Lieut. G. M. Wheeler to the Chief of Engineers, 1877, p. 350, as not cer-

tainly distinct from *Dicrocerus* Lartet. The discovery of a second species of the group, which displays the characters there pointed out, in a still more striking degree than the species on which it was formed, renders it necessary to introduce the genus formally to the system. In brief its molars differ from those of *Dicrocerus* much as those of the deer differ from the molars of the antelope. While *Dicrocerus* was probably the ancestor of *Antilocapra*, *Blastomeryx* was the ancestor of *Cervus* or *Cariacus*.

The superior dental formula is I. 0; C. 0; Pm. 3; M. 3. The molars all have two pairs of crescents excepting the last premolar, where the posterior pair are rudimental. The external face of the anterior crescent in all the molars presents a groove, which is bounded posteriorly by a vertical ridge. The posterior crescent is directed a little inward posteriorly on the true molars. The palate is much contracted in front of the first molars. The horns stand above the posterior parts of the orbits; their section is triangular, the posterior angle being rounded, and the external produced and acute, bounding the orbit outwards and backwards. There is no trace of burr. The temporal fossæ approach so as to be separated only by a rather wide and low occipital crest.

Measurements.	M.
Total length of skull	.320
Length of molar series	.107
" premolar "	.049
" second premolar	.016
Width " "	.011
Length of first true molar	.020
Width " "	.015
Width between bases of horn-cores	.050
Transverse diameter of horn-core two inches from base	.040
Width between external borders of first true molars	.078
Width of palate in front of first premolars	.028

This species was as large as the black-tailed deer, *Cariacus macrotis*. It was found by my assistant, J. C. Isaac, in the Upper Miocene of Montana.

CERVUS FORTIS sp. nov.

This deer is of large size, much exceeding any living species of the family *Cervidæ*. It is represented in my collections by a superior molar of the left side, and very probably by other remains which accompanied it, viz.: a mandibular symphysis with incisor and canine teeth; calcaneum. astragalus, vertebræ, etc. These were found at the same time and place by George M. Sternberg, M.D., U. S. A., already well-known by his interesting discoveries in the cretaceous formation of Kansas.

The plicæ which mark the anterior extremities of the external crescents are very prominent, and are directed forwards rather than outwards. The median lakes are narrow and well separated medially. The posterior lake has a strong fold of its internal border, forming a lobe directed backwards.

A cylinder of small diameter stands near the apex of the fold of the internal enamel wall, which separates the internal crescents. There is a cingular ridge descending inwards on the interior and posterior extremities of the base of the crown, and below and exterior to it the enamel surface is very rugose. The surface of the external enamel is smooth. The enamel of the lake borders is seamed with shallow vertical sulci. The crescents are wide and the lakes narrow.

The reference of this species to the genus *Cervus* may require reconsideration.

Measurements.	M.
Anteroposterior diameter of crown	.052
Transverse do. in front	.035
Width of anterior external crescent	.018
Elevation of crown externally	.020

From the pliocene formation of Oregon.

The Loup Fork beds have been usually referred to the Pliocene horizon, but I have offered reasons why they should be regarded as of Upper Miocene age. The horizon from which this and some other species herein described, found in Oregon, represent the Pliocene formation much more nearly.

DICOTYLES SERUS, sp. nov.

This species of hog is indicated by a mandibular ramus which lacks the angles, and supports the dentition of both sides excepting the third right molar. Other portions of the skeleton are associated. A second specimen is the symphysis with the incisor teeth. The remains indicate an animal something larger than the white lipped peccary *Dicotyles labiatus*.

Dentition of the mandible, I. 2 ; C. 1 ; P. m. 3 ; M. 3. Inferior canines triangular ; superior canines decurved, triturating the inferior. Last inferior molar with well developed heel. Last premolar like the first molar. First premolar with anterior single tubercle and posterior lower tubercle heel ; second premolar similar but wider, and the anterior tubercle divided. Molars consisting of four principal tubercles opposed in pairs, with some accessory ones between them.

The rami are robust and of moderate depth ; the symphysis is elongate and contracted. The suture of the latter remains on the inferior side, but is obliterated on the upper surface. The symphysis is trough-like and the narrow alveolar ridges of the diastema are concave inwards.

The incisor teeth are directed forwards, and are closely approximated and parallel. The fang of the second lies close to that of the canine, and the edges of the crowns together form a parabola, the enamel being prolonged posteriorly on the external side of the external tooth. The crowns of the median teeth are not expanded laterally, nor much depressed at the apex ; as half worn in the specimen, they form a wide transverse oval. The canines curved upwards and outwards and present their triturating surface a little external to directly backwards. Their section is tri-

angular, the lateral faces being longer than the posterior, and the anterior angle is a narrow one. The surface of the enamel cannot be described, as it is eroded at some points. The diastema is long.

The first (homologically second) premolar is narow, and is without lateral or posterior lobe or cingulum, but a third is a rudimental lobe at its anterior base. The heel presents an interior tubercle, and a narrow postero-external lobe which embraces a medeo-external tubercle. The latter becomes the external posterior tubercle on the true molars. The third premolar is larger and wider than the second; the medio-external lobe becomes more external and posterior, and a median tubercle appears in front of it. The posterior tubercle still sends a narrow ledge round to the outer base of the medio-external lobe. The anterior lobes are more elevated than the others, and are only separated by a fissure. In the fourth premolar the true molar structure is seen in the regular quadri-tuberculate form. There is a small tubercle in front and behind the notch of lobes, and a fold descending forwards on the outer side of the external posterior lobe. In the second true molar there is an additional tubercle on the middle line between the pairs of lobes. The median accessory tubercles are not distinct on the last molar, excepting the posterior, which becomes a large heel. The lobes of each pair are not deeply separated on the last two molars. These teeth are rather abruptly larger than the first true molar, which is little larger than the last premolar. Each of them has a narrow anterior cingulum, but no other. The enamel is nearly smooth.

Measurements.	M.
Length of mandible from end of posterior molar to incisive alveoli	0.190
Length of molar series	.103
" true molars	.062
" diastema	.054
Width between bases of canines	.020
" of diastema	.024
" between bases of first premolars	.032
Diameter of p. m. 2 { antero-posterior	.012
Diameter of p. m. 2 { transverse	.007
Diameter of p. m. 4 { transverse	.015
Diameter of p. m. 4 { antero-posterior	.012
Diameter of m. 2 { antero-posterior	.021
Diameter of m. 2 { transverse	.016
Diameter of m. 3. { antero-posterior	.026
Diameter of m. 3. { transverse	.015

The animal from which the above description was taken was adult. It was discovered in the Loup Fork beds of North-Western Kansas by Russell Hill of this city.

TETRALOPHODON CAMPESTER sp. nov.

The cranium and under jaw, with nearly complete dentition, including tusks, of this species, were obtained by my assistant, Russell S. Hill. The

animal is mature but not old, as the second true (third intermediate) molar is present and much worn, and the last molar is worn on its anterior three-fifths.

The posterior or fourth crest of the second true molar is narrower than the third, and is not followed by a heel. The third molar presents six transverse crests, and so large a heel that it might be said to be seven-crested. Each crest is sub-transverse, and is composed of a principal obtuse cone at each extremity and some smaller ones between, in close contact. The apices of the larger ones approach each other, and the median ones are less elevated. The section produced by wearing of the third and second crest each, is that of two trefoils placed base to base, and the lateral lobes of these, completely close the valley between those crests. The valleys between the other crests are closed by one or two distinct median tubercles, and the sections of those crests are less accurately trifoliate than those of the others. There is a very large cingulum at the anterior extremity of this tooth whose worn section is confluent with both of the trefoils of the anterior crest near the middle. A portion of it is isolated on the inner side of the crown, forming a flattened cone, or when worn, an isolated oval with the long axis directed inwards and forwards. This I have counted as the first crest, as it is as much entitled to it as the one so counted by Dr. Falconer, in the *T. sivalensis*. The palate is narrow, not exceeding the width of the second true molar.

The mandibular rami are of rather light tissue, and are compressed in form, the external face being little convex. The symphysis is produced, without abrupt contraction either laterally or below, into a robust beak whose depth is equal to the width five inches beyond the bifurcation. It is channeled above by a narrow and deep groove, and supports no tusks. From the appearance of the tissue when fractured transversely it is evident that there have been no alveolar cavities at any time. The beak is slightly decurved and the extremity is depressed and transversely flattened. The superior incisor possesses a broad band of enamel, which covers nearly one-third the diameter of the tooth.

Measurements.	M.
Length of crown of second true molar	.118
Width " " "	.075
Length " third "	.195
Width " " "	.080
" palate at anterior extremities of second molars	.045
" " posterior crests of third "	.095
Length of ramus from posterior border to bifurcation	.560
Length of symphyseal beak (broken)	.480
Depth of do. five inches from bifurcation	.118
Width of do. at do.	.115

This fine new *Mastodon* is the second species of the genus *Tetralophodon* found as yet in North America, the first being the *T. mirificus* of Leidy.

It is well distinguished from this form by the structure of the component parts of the crown of the last molar tooth, and by its long symphysis, that of the *T. mirificus* possessing the more usual short spout. It is with the *T. longirostris*, of Eppelsheim and the valley of the Danube, that the closest affinity exists. In *T. campester* the symphyseal production is much more robust, not being separated from the rami by any constriction, as in *T. longirostris*. It is moreover without incisive tusks, but it is yet uncertain what value should be attached to this character, as it may turn out to be individual or sexual. In the intimate structure of the molars there is considerable resemblance to the *T. longirostris;* that species is however stated by Dr. Falconer* to possess but five crests and a heel on the last molar. The presence of the enamel band on the tusks also separates the *T. campester* from that species, where, according to Mr. Vacek,† it is wanting.

In comparison with *M. sivalensis*, this Mastodon differs in the transverse character of the valleys; in the Indian species the tubercles alternate and close them.

The dimensions of the *T. campester* are those of the African Elephant.

From the Upper Miocene and Loup Fork horizon of Kansas.

Taxidea sulcata sp. nov.

This badger is represented by the nearly entire maxillary bone of the left side containing all the teeth excepting the canine and first premolar. It resembles the corresponding portion of the *T. americana* very nearly, but differs in two important features. The first of these is the abbreviation of the anterior portion of the dental series. The first premolar is closely wedged in between the canine and second premolar, so that its anterior root is almost obsolete. The head was thus doubtless relatively shorter than in the existing species where there are hiatuses between the roots of the first premolar and adjacent teeth. The second character is seen in the last or true molar. On its crown the tubercles are arranged in two well separated transverse rows, forming crests by their confluence, which are separated by a deep valley, and bound by a half valley in front and rear.

Measurements.	M.
Length of series, including canine	.038
" premolars	.023
" last premolar	.011
Width of " "	.009
Length of last molar (inside)	.012
Width " "	.010

From the Pliocene of Washington Terr.; found by Major Truax, U.S.A.

* On British and European Fossil Mastodons, p. 19 (8 vo.).

† Ueber Oesterreichische Mastodonten Wien, 1877, p. 31 (Abh. K. K. Geol. Reichanstalt).

PSEUDEMYS BISORNATUS sp. nov.

This fresh water tortoise is represented by portions of three individuals. These exhibit a rather flattened convex carapace, with marginal bones united (behind the bridge at least), without gomphosis, by fine suture. There are no median or lateral keels. The vertebral bones are nearly as wide as long, and thick; the costals are thickest proximally and thinnest medially. The marginals are quite stout. The dermal scutal sutures are deeply impressed, especially those defining the marginal scuta.

The sculpture of the superior surface of the carapace is strongly marked and peculiar. The vertebral scutal areæ are smooth, or display only a few obscure ridges directed backwards and inwards, on the proximal portions of the costal bones; the vertebral bones being smooth. The costal scuta present two forms of sculpture; posterior to the intercostal bony suture each is reticulated with inosculating sharp ridges whose general direction is longitudinal proximally and transverse distally. The sculpture is Trionyx-like, and rather coarse. The surface anterior to the osseous suture, is ornamented with raised, parallel ridges, which are separated more widely than those of the posterior half of the scutum, and which do not inosculate. They continue uninterruptedly to the succeeding osseous suture, to be followed again by the reticulate pattern. Thus each costal bone is divided into three areas; a proximal smooth one, and an anterior reticulate, and posterior ridges areæ, separated by a deep sutural groove.

A postero-lateral marginal bone unites subequally with two costals. Its superior surface rises in abrupt convexity beyond the costo-marginal dermal suture, and from the transverse intermarginal dermal suture. It is then concave to the recurved margin. Its sculpture consists of transverse ridges, separated by grooves of equal width.

Measurements.	M.
Length of a vertebral bone	.035
Anterior width of same	.032
Thickness of same anteriorly	.009
Extent of median costal { antero-posterior	.035
Extent of median costal { transverse	.117
Median thickness of do	.006
Distal " "	.007
Length of a posterior marginal	.030
Width " "	.042
Thickness " "	.017

This tortoise is at first sight apparently singular in its marks of ornamentation. On comparison with existing species, however, it is seen to present an exaggerated condition of the sculpture characteristic of some of the existing *Pseudemydes* of our Southern rivers; e. g. the *P. elegans*. It is more robust in all its proportions than any of these.

The fossil remains were discovered by my friend, G. W. Marnock, in the pliocene of South-western Texas.

CISTUDO MARNOCHII.

Represented by the posterior lobe of the plastron of an individual of twice the bulk of the existing North American *Cistudos*. It is broadly rounded posteriorly, and there is an emargination at the femoro-anal dermal suture. The anterior suture is straight, as is also the lateral, which measures more than a third the length of the entire lobe. On the upper side of the angle included by these sutures is the fossa for fixed attachment with the carapace. The beveled face of the fore edge of the lobe is quite wide. The dermal sutures are well marked. The anal scuta are large, their median length being half that of the lobe. The common femoral suture is only half as long as the ventral. The inferior surface is nearly flat in every direction; and the surface is smooth. The posterior border of the specimen is broken away.

This species was obtained from the same formation as the last, by Gabriel W. Marnock, to whom I dedicate it.

ANCHYBOPSIS BREVIARCUS sp. nov.

The genus to which the above name was given, was established by the writer in 1870, for a species Cyprinoid fish, from the pliocene formation of Idaho. Its affinities were then stated to be to *Alburnops* (*Hybopsis*), and related existing genera. The present paper describes two additional species of the genus, both of which are represented by pharyngeal bones and teeth of both sides. The teeth are shown to be 5–5, in contradistinction to the genera *Hemitremia* and *Alburnops*, where they are 5–4 and 4–4 respectively

In this fish the common base of the pharyngeal teeth rises upwards, so as to project well in front of the general plane of the bone. The superior teeth are more compressed than the inferior, and the first and second counting from below, have convex grinding faces. The pharyngeal bone has a short inferior and a long superior limb. The alate portion is regularly and strongly convex, without abrupt expansion. The nutritive foramina of the anterior face are two large inferior and several small superior ones.

Measurements.	M.
Vertical extent of bone in a straight line	.020
Width at second tooth	.008
" at first "	.004
Length of tooth line	.011
" of third tooth	.005
" of basal limb to first tooth	.009

This species is of smaller dimensions than the *A. latus*.

ANCHYBOPSIS ALTARCUS sp. nov.

The pharyngeal bones of this cyprinoid are larger and of more slender proportions than those of the *A. breviarcus*. Specimens from both sides are preserved. The inferior and superior limbs are both elongate, the former slender, the latter flat. The ala is abruptly expanded at right angles to the long axis; the external border is thence nearly straight to, and the angle of

the superior border situated interiorly to, the line continuing the inner border upwards. The tooth line is elevated at the upper extremity. The basal teeth are more robust than the others, and do not present grinding faces. The nutritive foramina are more numerous and smaller than in the *A. breviarcus*.

Measurements.	M.
Vertical extent of right pharyngeal	.023
Width at second tooth	.009
" at first "	.004
Length of tooth line	.012
" of third tooth	.006
" of basal limb to first tooth	.011

Found with the last species by Chas. H. Sternberg, in the Pliocene deposit of Oregon.

ALBURNOPS ANGUSTARCUS sp. nov.

Represented by the pharyngeal bones of both sides, of a species of about the size of the one last described. The characteristic marks of these are seen in the long extremities, both inferior and superior, and in the very slight convexity of the ala, which is less prominent than in any of the *Cyprinidæ* here described. The superior end of the tooth basis is elevated and prominent. In one of the jaws all the teeth display a masticating surface. In the other the second tooth, the only one preserved, is partially worn.

The length of the proximal limb distinguishes this pharyngeal bone from that of the *Anchybopsis breviarcus*, if the generic characters be disregarded. From all the other species the slight prominence of the ala separates it.

Measurements.	M.
Vertical extent of right pharyngeal	.023
Length of proximal limb	.010
" of tooth line	.010
" of distal limb	.012
Width at first tooth	.005
" of second tooth	.007
Length of third tooth	.005

Found by Mr. Sternberg, with the last species.

ALBURNOPS GIBBARCUS sp. nov.

One left and two right pharyngeal bones furnish the characters of this species. Their form is angulate, as in the *Anchybopsis altarcus*, but shorter in the vertical direction. The proximal limb is rather short, and the distal one not as long as in the species last described. The ala widens abruptly at the inferior margin, and the thin superior edge of the superior limb is obtusely angulate. The nutritive foramina are rather numerous. The first and second teeth display little or no grinding surface.

Measurements.	M.
Vertical extent of right pharyngeal	.020
Length of proximal limb	.009
" of tooth line	.009
" of distal limb	.009
Width at first tooth	.004
" at second tooth	.008
Length of third tooth	.005

Found by Chas. H. Sternberg in the Pliocene of Oregon.

On some Saurians found in the Triassic of Pennsylvania, by C. M. Wheatley.

By E. D. Cope.

(*Read before the American Philosophical Society, Dec.* 21, 1877.)

THECODONTOSAURUS GIBBIDENS sp. nov.

The only remains of this saurian which have come into my hands are two teeth. They are in good preservation, lacking only the great part of the root. They present the leaf-like outline characteristic of the genus, the crown being strongly distinguished from the narrower root. The form is quite robust, and contracts gradually to the apex. The cutting anterior and posterior edges bound the inner face of the crown, from which they are separated by a groove along their bases. They are interrupted by coarse serrations, the apices of the denticles being directed upwards. These are much reduced in size at the base of the crown. The cutting edges are not separated from the external face by grooves. This face is very convex and perfectly smooth. The inner face is convex between the grooves and is marked with six or seven continuous sulci, which are obsolete at the base.

The saurian which possessed the tooth described was not of large proportions. The species differs from the English form in many respects; e. g., the greater convexity of the external face; the basal grooves of the cutting edges, the grooving of the inner face, the abrupt constriction below the base of the crown, etc.

Measurements.		M.
Diameter of crown	antero-posterior	.0070
	transverse	.0045
Length of crown		.0038

PALÆOSAURUS FRASERIANUS sp. nov.

But few remains indicate this species. It is established primarily on a tooth, which presents the characters of *Palæosaurus cylindrodon*. It has opposite denticulate cutting edges, an anterior and posterior, of which the latter extends to the base of the crown, and the anterior but half way from the apex. The posterior is denticulate throughout, while denticulation is visible on the anterior edge for but one-third the distance from the apex. The posterior edge is more compressed. The surface of the cementum is obsoletely finely linear ridged, and there are no sulci or other sculpture. The crown is regularly and gently curved backwards.

Measurements.	M.
Length of the crown	.0200
Antero-posterior diameter of crown at base	.0065

This saurian is dedicated to my friend, Persifor Frazer, Jr., in charge of one of the districts into which the State of Pennsylvania is divided for the conduct of the second geological survey. This district embraces the Triassic region, which has been extensively and ably investigated by Prof. Frazer.

SUCHOPRION AULACODUS Cope.

Palæoctonus aulacodus Cope, Paleontological Bulletin, No. 26, p. 184.

Several additional teeth of this species show that the tooth from which I first determined it is one of the flattest of the series, and that those from other positions in the jaws, instead of being flatter as in *Palæoctonus*, are narrower, and of the usual form of those of *Suchoprion*.

This saurian possesses teeth of the size of the average of those of the *S. cyphodon*, and which are like them, well compressed in the antero-posterior direction. The surface is therefore very convex between the cutting edges, especially on the external face, and the transverse diameter at the base of the crown exceeds the antero-posterior. The cutting edges only extend half way from the apex, and are but little denticulated. The surface of the cementum is minutely and sharply linearly sculptured. It is in addition, thrown into coarse continuous grooves on the basal two-thirds of the crown, excepting for a short distance on the inner side of each cutting edge. There are seven grooves on the inner face, and eighteen on the outer face. On the latter the minute sculpture is least distinct.

Measurements.		M.
Length of crown		.0260
Diameter of base of crown	fore and aft	.0160
	transverse	.0115

The short slightly denticulate cutting edges and the strongly grooved surface distinguish the anterior teeth of this species at once from the *S. cyphodon*. Several specimens have been found by Mr. Wheatley.

On the Vertebrata of the Dakota Epoch of Colorado.

By E. D. Cope.

(*Read before the American Philosophical Society, December* 21, 1877.)

Not long since I was informed by the Superintendent of Public Schools of Fremont County, Colorado, Mr. O. W. Lucas, that he had discovered the bones of an enormous saurian at an outcrop of the rocks of the Dakota group not far from Canyon City. I encouraged him to proceed with the exploration, and asked him to send some specimens which would explain the character of his discovery. One of the first objects sent, is a fragmentary lower jaw of a carnivorous dinosaurian, which he found on the surface of the ground. This fossil was found to belong to a species heretofore unknown, which I referred to the genus *Laelaps*, under the name of *Laelaps trihedrodon*.* The second sending included a number of vertebræ, which apparently represent a much more gigantic animal, and I believe the largest or most bulky animal capable of progression on land of which we have any knowledge. This reptile I described in my paleontological bulletin No. 26, under the name of *Camarasaurus supremus*. Subsequent sendings included many of the more important bones of the skeleton, which render it comparatively easy to determine the general character of this monster. Later collections received from Mr. Lucas include the teeth of two large species of a new genus which has been characterized under the name of *Caulodon;* and the vertebræ of three genera new to science, which I have named *Tichosteus*, and *Symphyrophus*. He also procured remains of two additional forms of gigantic size, fit rivals of the *Camarasaurus*, which I referred to the new genus *Amphicœlias*. A species of tortoise was associated with these saurians, and appears to have been abundant. It is the oldest species of the order yet obtained from American formations, and is not very different from existing forms.

The above named genera are the only ones from the Dakota horizon of this continent which have been defined, up to the present time.

The species of *Camarasaurus* and *Amphicœlias*, which attained to the most gigantic proportions, are remarkable for the light construction of the vertebræ anterior to the tail. In both genera the centra of the dorsal vertebræ are hollow, including two large chambers which are separated by a longitudinal median wall, and which communicate with the cavity of the body by a foramen on each side. They are also remarkable for the enormous elevation of the superior arches, and diapophyses, the result of which is to give the ribs an unusually elevated basis, and the cavity of the body much space above the vertebral axis on each side. On the other hand the bones of the tail and limbs are solid or nearly so, in great contrast with some of the *Dinosauria* of later geological periods. Another peculiarity of the genus *Camarasaurus* at least, is the probable great length of the an-

* Bullet. U. S. Geol. Surv. Terrs. III, 1877, p. 805.

terior limbs. The scapula is enormous as compared with the pelvic bones. The sacrum is also small and short, showing that the weight was not borne on the hinder limbs. The great length of the humerus in the probably allied genus *Dystrophæus*, from the Trias of Utah, adds to the probability that the same bones were large in *Camarasaurus*. This character, taken in connection with the remarkably long neck possessed by that genus, suggests a resemblance in form and habits between those huge reptiles and the giraffe. While some of the later *Dinosauria* elevated themselves on their hind limbs to reach the tree-tops on which they fed, the general form of the body in some of these earlier types enabled them to reach their food without the anterior limbs leaving the earth.

Another remarkable peculiarity which these genera share with *Dystrophæus* and *Cetiosaurus* is the irregular and pitted character of the articular extremities of some of the bones. This indicates a cartilaginous covering, and probably in some instances an osseous cap or epiplysis.

Dr. Hayden visited the locality of Mr. Lucas' excavations, and informs me that the formation from which the *Camarasaurus* was obtained, is the Dakota. Prof. Marsh has attempted to identify what is, according to Prof. Mudge, the same horizon, one hundred miles north of Canyon City, with the Wealden of England. Specimens from the northern locality which I have examined render it certain that the horizon is that of Mr. Lucas' excavations. Of this I may say that there is no paleontological evidence of its identity with the Wealden. The resemblance of the vertebrate fossils to those of the English Oolite is much greater, but not sufficient as yet for identification.

The discovery of *Vertebrata* in the strata of the Dakota epoch is an important addition to the geology and paleontology of North America. The numerous geologists who have explored its outcrops have failed hitherto to observe remains of this class of animals. Credit is due to Superintendent O. W. Lucas for this discovery, and also in an especial manner for the skill and care he has exercised in taking out and shipping the ponderous specimens.

CAMARASAURUS Cope.

Palæontological Bulletin No. 25, p. 5; (published August 23, 1877).

The characters of this genus are derived from nearly all portions of the skeleton excepting the skull and ungues. The bones are generally in good preservation.

The vertebræ of the cervical, dorsal and lumbar region are all opisthocœlous or reversed ball and socket. The centra of the cervicals are very elongate, but those which follow them diminish rapidly in length, until in the lumbar region they have but a small anteroposterior diameter. The anterior caudal vertebræ are also very short and wide; but the length of the centra gradually increases, so that the distal ones are quite elongate. The caudal centra are all moderately amphicœlous.

The centra of the cervicals and dorsals are hollow, and the interior

chambers communicate with the cavity of the body by a large foramen on each side, which is below the base of the diapophysis. In the cervical vertebra it is very elongate, and extends between the bases of the parapophysis and diapophysis. In the dorsal centra there are but two chambers, which are separated by a longitudinal median septum.

The neural arches are coössified with the centrum throughout the column. They are extraordinarily elevated, and their antero-posterior diameter is small. The zygapophyses are at its summit, and have extensive articulating surfaces. The anterior pair are divided by a deep median fissure, while the posterior are united, and support as a pendant from their inferior median line a *hyposphen*, a structure more fully described under the head of the genus *Amphicoelias*, where it is equally developed. When the vertebræ are in relation, the base of the hyposphen enters the fissure between the anterior zygapophyses, and maintains them in position. This structure is obsolete in the lumbar vertebræ.

The diapophyses rise from the neural arch to a considerable length upwards and outwards, in the anterior dorsals. They become shorter posteriorly, but in none of the vertebræ anterior to the sacrum do they issue from the centrum. In the caudal vertebræ they are short and robust, and issue from the superior part of the centrum, They do not continue far on the tail. Those of the dorsal vertebræ are light and concave below. They are supported by thin osseous buttresses, the most important of which are the two inferior ones. The anterior of these is much the most prominent, and bears the capitular articular facet for the rib. In no case is this surface seen on the centrum, but it descends somewhat in the posterior vertebræ, but not as low as the level of the neural canal.

The neural spines are rather short, and are set transversely to the axis of the animal. The superior portion is expanded transversely, and in an anterior dorsal vertebra, is widely emarginate above, so as to appear double. The neural spines of the caudal vertebræ are compressed and elevated, though thickened at the apex. The zygapophyses are situated low down, and are directed very obliquely. The chevron bones of the caudal vertebræ have short limbs which are not united at the base, and a long common median spine.

The sacrum is short and consists of only four vertebral centra, thoroughly coössified. The anterior articular extremity is convex; that of the posterior extremity slightly concave. Its transverse processes are, like those of the other vertebræ, much elevated, although they spring from the centra. The external face of their bases is not prominent, and the spaces between their projecting portions are deeply excavated. The centra are like those of the caudal vertebræ, composed of dense bone. The extremities of the adjacent transverse processes are united, thus enclosing large foramina.

The scapula is relatively of large size. It is rather elongate, and the superior extremity is expanded. There is a very large mesoscapular process, which is wanting in *Cetiosaurus*, according to Phillip's figures. It appears to resemble the scapula in *Dystrophæus*.* The two proximal faces,

* See Report of Lt. Wheeler, Vol. IV, pl. LXXXIII, p. 31.

the glenoid and the coracoid, are well distinguished, and their surfaces are like the corresponding faces of other bones, pitted coarsely.

The coracoid bone is of proportionately small size. It is of an irregularly quadrate form, with the proximal extremity the shortest. The articular face is large, and is presented obliquely away from the long axis of the plate. There are no emarginations nor intermediate processes, and the perforating foramen is well removed from the border.

Pelvic bones of two forms are present. Neither of them resembles pelvic bones of *Dinosauria*, and are least of all similar to the forms of ilium which are known in that order. One of them is a robust L-shaped bone, one limb of which is expanded into a wide fan-shaped plate; and the other is stouter and of sub-equal width, terminating in a stout sub-triangular articular extremity. The face of this limb of the bone which looks away from the fan-shaped plate is concave throughout its entire length, forming a large part of the acetabulum. Both edges of this cavity are free and rounded. The absence of articular faces above the acetabulum renders the identification of the bone with either pubis or ischium difficult. The second pelvic bone is larger than the first, and unlike it, is in one plane. Its form is that of a low triangle with a long base, at each extremity of which the angles are truncated. The "basal" border is gently concave in the long direction and thick and convex in the cross-section, The two "sides" of the triangle are rather thin margins, but one of them is thicker than the other. One extremity of the bone is more robust than the other, and is divided into two planes. The one is transverse and sub-triangular, and applies to the extremity of the stout or acetabulum limb of the other pelvic bone. The other is smaller, is oblique and concave, and when the two bones are placed in relation, forms a continuation of the acetabular surface already described. Within this and the proximal portion is a large foramen which resembles the pectineal perforation of the pubis.

The femur is long and without prominent third trochanter, this process being represented by a low ridge. The condyles have an extensive posterior sweep, and are separated by a shallow trochlear groove in front. A tibia which was found with the other bones, is much shorter than the former, and has a much expanded head. It is very robust, especially at the distal extremity. The astragalus was evidently distinct from it. A metapodial bone is very robust. Its extremities are much expanded, and the shaft contracted, and it is furnished with a prominent median keel on one half of its posterior aspect.

Several genera have been described, which possess some of the features presented by those to which the present animal belongs. The following are characterized by the presence of the lateral sinuses of the vertebral centra: *Megadactylus* Hitch., *Cetiosaurus* Owen, *Ornithopsis* Seeley, *Bothrospondylus* Ow., and *Pneumatarthrus* Cope. The first of these may be dismissed with the remark that its caudal vertebræ possess the sinuses as well as the dorsals, which we have seen is not the case with the Colorado animal. The centra of *Cetiosaurus* according to Owen, and those of

Pneumatarthrus, do not exhibit the cavernous structure above described, but are uniformly spongy interiorly. *Ornithopsis* of Seeley, which Owen refers to his subsequently described *Bothrospondylus*, possesses a cavernous cellular structure, which I have not found in the reptile from Canyon City, Colorado, but which occurs in the huge saurian discovered by Prof. Lakes, near Golden, Colorado, in the same stratigraphical horizon. Another name (*Chondrosteosaurus*) has been introduced by Prof. Owen, but he gives no characters, nor points out how it differs from *Ornithopsis*, which it resembles in its cellular structure.

A short time prior to my publication of the description of the genus *Camarasaurus*, Prof. O. C. Marsh of New Haven issued a description of a portion of a sacrum of a saurian found in the Dakota beds near Morrison, Colorado, a point one hundred miles north of Canyon City. To the animal to which the sacrum belonged, Professor Marsh gave the name of *Titanosaurus montanus*. As the name of the genus was not accompanied by any generic diagnosis or specific reference to its characters, it has no claim to adoption according to the rules of nomenclature, nor is the genus distinguished from some of those above enumerated. Especially is there nothing to indicate that it differs from *Ornithopsis* or *Bothrospondylus*. The name given has also been already employed by Dr. Lydekker of the Geological Survey of India.

CAMARASAURUS SUPREMUS Cope.

Paleontological Bulletin, No. 25, p. 7; Aug. 1877.

The bones of this species so far discovered by Mr. Lucas are:—a cervical and twenty dorsal and lumbar vertebræ, with twenty caudals. Both scapulæ and coracoids were recovered, with one-half of the sacrum, and two pairs of pelvic bones. Of the hind limb I have the femur, with a tibia less certainly belonging to the same animal, although found among the other bones. There is one metapodial. There are many other bones which I have not yet reconstructed or determined.

The dimensions of this animal may be inferred from the fact that the cervical vertebra is twenty inches in length and twelve in transverse diameter; and that one of the dorsals measures three and a half feet in the spread of its diapophyses, two and a half feet in elevation and the centrum thirteen inches in transverse diameter. Another dorsal is two feet ten inches in elevation. The scapula is five and a half feet in length and the femur six feet.

The centra of these vertebræ bear a ball and socket articulation of the opisthocoelian type, the cups and balls being well pronounced; just beneath the diapophysis is situated a huge foramen. A broken centrum from which Mr. Lucas removed the matrix, shows that this foramen communicates with a huge internal sinus, which occupies almost the entire half of the body of the vertebra. Those of opposite sides are separated by a septum which is thin medially. Thus the centra of the dorsals are hollow. The neural arches are remarkable for their great elevation, and the great expanse of the zygapohpyses. They are more remarkable for the

form of the neural spines, which are transverse to the long axis of the centrum. That of one of the vertebræ is strongly emarginate so as to be bifurcate. The widely extended diaphophyses support the rib articulations, and there are no capitular articular facets on the centra.

The cervical vertebra is depressed, the anterior or convex extremity of the centrum the most so. It is remarkable for its elongate form, exceeding the proportions found in known *Dinosauria* and *Crocodilia*, and resembling that seen in some fluviatile tortoises. Near the anterior extremity a short, robust parapophysis has its origin, from which it extends outwards and downwards, and soon terminates in a truncate extremity which presents downwards. A deep fossa occupies its upper base, and above this a deep linear foramen extends throughout the greater part of the length of the centrum. If this vertebra possesses a diapophysis it is rudimental.

The caudal vertebræ are amphicœlian, but not deeply so. They are subquadrate in section, and not so short as the corresponding ones of *Hadrosaurus*. The most anterior one of the series has short, robust diapophyses, and is more concave anteriorly than posteriorly. The other caudals are more equally biconcave, but the cavity is very shallow on the most distal of them. The centrum is relatively more elongate and compressed than those of the others. None of them display the lateral pneumatic fossa which exists in the dorsals, and where broken so as to permit a view of the internal structure, the latter appears to consist of rather finely spongy tissue. The chevron facets are not very well defined, and the neural spines are of usual forms, and on two anterior vertebræ elongate.

Many peculiarities are exhibited by the vertebræ of this species, which are not described in saurians known up to the present time. Many of these would have been lost in less careful hands than those of Mr. Lucas, and science is much indebted to him for the preservation of many walls and buttresses of light proportions. In general the external walls of the centra are thin, and the processes are composed of laminæ united by narrow margins. The vertebræ are lighter in proportion to their bulk than in any air-breathing vertebrate.

The anterior extremity of the centrum of the cervical vertebra is prominently convex, and much depressed. The posterior and concave extremity is wider, and of rather greater vertical diameter. The base of the neural arch only occupies half of the length of the centrum, an equal extent of the superior surface extending freely beyond it at its anterior and posterior extremities.

The linear lateral foramen commences a little behind the anterior base of the neural arch, and descending somewhat in its direction, terminates beneath the posterior extremity of the base of the neural arch. The base of the latter overhangs the foramen and the base of the transverse process. The interior surface of the centrum is concave, the concavity being bounded in front by the inferior convex thickening of the extremity. Behind the middle the surface becomes plane, and is, near the posterior extremity, bounded on each side by a short angular ridge.

Measurements.	M.
Length of centrum between anterior convexity and posterior lip	.565
Depth of posterior cup	.090
Diameter of cup, vertical	.310
Diameter of cup, transverse	.160
Length of parapophysis	.095
Width of neural canal	.063

The dorsal vertebra which I suppose the anterior one of those received, is characterized by the lack of the median portion of the neural spine, and the extension outwards of the median lateral processes described above. The diapophyses are much longer, and the zygapophyses more extended transversely. The centrum is constricted at the middle, and especially just behind the convex articular extremity, whose circumference forms a prominent rim. The edges of the lip are flared outwards, forming a deep basin, much wider than deep. The fossæ described in other vertebræ are present in this one, but differs in proportions, owing to the greater size and expanse of the superior parts of the neural arch. The fossa posterior to the base of the diapophysis is nearly plane, while that at the anterior base is deeply excavated, is narrower, and extends so far along the inferior side of the process as to give it a semi-circular section near the middle. Distally the diapophysis has a trialate section, owing to its three longitudinal ridges, and the articular extremity is large and antero-posterior in direction. The process differs from that of the vertebra next described, in the possession of a facet near the middle of its anterior inferior bounding ridge, which is probably costal, as in the vertebra of *Crocodilia*. The lateral foramen of the centrum is subround. The general surface is smooth.

Measurements.	M.
Total elevation of vertebra	.770
" transverse extent of diapophyses	1.010
Diameter of centrum, longitudinal	.300
Diameter of centrum, vertical of cup	.250
Diameter of centrum, transverse of cup	.340
Diameter of centrum, " at middle	.205
Elevation of zygapophysis above centrum	.310
Diameter of zygapophysis, transverse	.170
Diameter of zygapophysis, antero-posterior	.090
Width of neural canal	.085
Transverse extent of neural spine	.440
Length of diapophysis from posterior zygapophysis	320
Antero-posterior width of end of diapophysis	.135

A dorsal vertebra from a more posterior position, is characterized by its undivided transverse neural spine. The entire neural arch is of enormous elevation, but as the zygapophyses are above its middle, the neural spine is not as long relatively as in various other genera or as in the

caudals of this one. The sides of the centrum are strongly concave, and the borders of the cup flaring. The neural arch is everywhere excavated, so as to reduce the bulk, and produce lightness so far as consistent with strength. The diapophysis rises from a point above the neural canal. It sends a narrow ridge down to the sides of the latter, on each side of which its shaft and base are deeply excavated. The posterior of these fossæ is overlooked by the wide zygapophysis; and the roof of the anterior one supports the anterior zygapophysis. The former are separated by another and vertical septum, which bifurcates below, forming two prominent borders of the neural canal. At each side of the base of the neural canal there are two trilateral fossæ, of which the anterior is much the larger and extends higher upon the lateral edge of the spine, They are separated by a lamina. The diapophysis is not very long and is subtriangular in section near the extremity. The neural spine is thickened at the extremity as though for the attachment of a huge ligament, At the summit of its posterior basal fossa, at the middle of its height, is an outwardly curved process with a smooth extero-superior face.

Measurements.	M.
Length of centrum	.275
Total elevation of vertebra	.830
Elevation to posterior zygapophyses	.550
" of superior edge of diapophysis above centrum	.350
" " neural spine above posterior zygapophyses	.295
Length of diapophysis behind	.215
Depth of extremity of do. (restored)	.075
Transverse extent of summit of neural spine	.215
" " neural spine at middle	.330

In a dorsal vertebra from a more posterior position, the centrum is larger. The capitular costal articulation occupies a lower position, its inferior edge being in line with summit of the neural canal. The lamina which supports it is separated from the anterior lamina which is at the base of the diapophysis, by a deep cavernous sinus. The posterior zygapophyses send upwards to the broad neural spine a median buttress each, which enclose a fossa with the marginal buttress of the same. The hyposphen is represented by a vertical lamina only.

	M.
Total elevation of vertebra	.900
Elevation of neural spine	.300
" " " distally	.280
Diameter posterior articular face of centrum	.360

A lumbar vertebra displays a greater expanse of the posterior articular extremity, which is expanded like a dish. The neural arch and transverse processes have a small fore and aft diameter, and the lateral caverns at the base of the diapophysis are obsolete. The pneumatic foramina are slightly higher than long. Posterior zygopophyses are wanting.

		M.
Diameter of centrum	vertical	.380
	transverse	.420
	antero-posterior	.170
Expanse of diapophyses		.590
Vertical extent of base of diapophysis to capitular surface		.200

A proximal caudal gives the following

Measurements.		M.
Total elevation		.560
Diameter of centrum	antero-posterior	.170
	transverse	.245
	vertical	.245
Antero-posterior diameter of neural spine		.075
Elevation of the neural canal		.040
Diameter of median caudal	fore and aft	.180
	vertical	.200
	transverse	.192
Diameter of posterior caudal	fore and aft	.155
	vertical	.175
	transverse	.145

A distal caudal of the elongate type has the following dimensions :

		M.
Diameter of centrum	antero-posterior	.155
	transverse	.125
	vertical	.100

The long diameter of the basis of the transverse processes of the large anterior caudal vertebræ is directed obliquely upwards and forwards. The anterior faces of some of these centra are flat.

The length of the sacrum is M. 0.900 ; elevation of first sacral rest, 0.500.

The head of the femur is subround. One side of the shaft is damaged, so that the form of its section cannot be ascertained. The side of the inner condyle is quite flat, and without epicondylar rugosity.

Measurement of femur.	M.
Length	1.820
Antero-posterior diameter of head	.310
" " " internal condyle	.450

The anterior and posterior edges of the scapula are thin. The posterior is slightly concave, with a slight projecting irregularity near the middle, and is then turned decidedly backwards, bounding the glenoid extremity. The glenoid face is concave, and longer than the coracoid suture. The anterior border is more strongly concave, the distal extremity being more expanded forwards. The sides of this extremity are slightly rugose with coarse grooves. The articular facets are pitted. A low keel extends along the external side of the mesoscapula.

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Measurements.	M.
Total length	1.517
Width distally	.680
" at middle	.325
" at mesoscapula	.810
Length of glenoid face	.400

The articular extremity of the coracoid is recurved and very robust. The borders of the bone are thick and roughened.

Measurements of Coracoid.		M.
Diameter	extero-internal	.690
	antero-posterior	.560
	vertical proximally	.

Measurements of Metapodial.		M.
Diameter proximally	transverse	.160
	antero-posterior	.095
Diameter medially	transverse	.075
	antero-posterior	.120
Diameter distally	transverse	.210
	antero-posterior	.105
Length		.270

That this species was capable of and accustomed to progression on land is certain from the characters of the bones of the limbs and their supports above described. The extraordinary provision for lightening the weight of a portion of the skeleton has more than one significance. It must be borne in mind that the caudal vertebræ retain the solid character seen in those genera which stood habitually on their hind limbs. That the present species was herbivorous is suggested simply by its huge dimensions, and the natural difficulty of supplying it with animal food.

AMPHICŒLIAS Cope.

Paleontological Bulletin No. 27, p. 2 (Published December 10, 1877).

The genus to which the above name is now given, is allied to *Camarasaurus*, of which, and the gigantic species *C. supremus*, I have given an account in my Paleontological Bulletin, No. 25. Both genera differ from their nearest ally *Ornithopsis* Seeley, in the excavation of the vertebral centra, so as to include large chambers separated by a septum, which communicate with the external medium by a lateral foramen. In the *Ornithopsis* it is stated that the vertebral centra are occupied by a number of coarse cells. In the more remotely allied *Cetiosaurus*, Owen has observed that the tissue of the centra is coarsely spongy.

The vertebræ from all parts of the column of *Camarasaurus* are known, and those of the dorsal and lumbar regions present the extraordinary character, of which a trace is seen in *Cetiosaurus*, of neural spines expanded transversely to the axis of the column. Numerous vetebræ of *Amphicœlias* are known, and in the dorsals in which the neural spine is preserved,

the latter displays the usual form, that is, it is compressed in the direction of the axis of the column. The centra differ from those of *Camarasaurus* in the form of their articular extremities, resembling more nearly in this respect the genus *Tichosteus* Cope (Paleontological Bulletin, No. 26, p. 194). They are unequally amphicœlous, the posterior extremity being more concave, and with prominent margins; while the opposite one is less expanded and is but slightly concave. The neural arch is coössified to the centrum, and there is no capitular costal articulation on the latter.

The manner of the mutual articulation of the neural arches in this genus is peculiar, and is only paralleled in the genus *Camarasaurus*, so far as I can ascertain. The anterior zygapophyses are separated by a deep fissure, while the posterior zygapophyses are united on the middle line. From the latter from the point of junction, there descends a vertical plate which rapidly expands laterally, forming a wedge whose base looks downward. The supero-lateral faces are flat, and articulate with corresponding facets on the inferior side of the anterior zygapophyses, which look downward and inward, on each side of the fissure above described. When in relation, the anterior zygapophyses occupy a position between the posterior zygapophyses above, and the *hyposphen*, as I have termed the inferior reversed wedge, below. This arrangement accomplishes the purpose effected by the zygosphenal articulation, that is the strengthening of the articulation between the neural arches, but in a different way. The additional articulation is placed at the opposite extremity of the vertebra, and it is the anterior zygapophysis instead of the posterior one which is embraced. This structure entitles the genera which possess it to family rank, and as the two genera mentioned above belong to different families in consequence of the different types of vertebral centra, the one opisthocœlous, the other amphicœlous, they may be called *Camarasauridæ* and *Amphicœliidæ* respectively.

The pubis is a stout bone with one slightly concave, thicker border, and an opposite strongly convex, thinner margin. One extremity is truncate; the other presents one transversely truncate and one oblique face. The femur is elongate, and presents a strong postero-external ridge or third trochanter near the middle of the shaft. The head is not separated by a well marked neck, and the great trochanter does not project beyond it.

Thus while there is a striking resemblance to *Camarasaurus* in what may be regarded as adaptive characters, in some important essentials the two genera are very different.

Amphicœlias altus Cope.

Paleontological Bulletin, No. 27, p. 3.

The centrum of the dorsal vertebra of this reptile is contracted both laterally and inferiorly, so that the margins of the articular extremities flare outwards. The sides are flat, and the inferior surface but little convex in the transverse direction. The pneumatic foramen is situated at the bottom of a large lateral fossa which extends nearly the entire length of the superior

portion of the centrum. Its inferior border is sunken abruptly, while the superior gradually shallows on the external surface of the base of the neural arch. The foramen is longer than high, in contradistinction to that of the *Camarasaurus supremus*, where it is round or higher than long.

The neural arch is very much elevated to the zygapophyses. It is strengthened by a prominent rib, which extends from the posterior base upwards and forwards to the base of the anterior zygapophysis. The surface above and behind this is occupied by an extensive excavation whose superior border is the line connecting the zygapophyses. The anterior zygapophyses are separated medially by a deep notch which extends to the base of the neural spine. The articular surfaces incline towards each other. Just behind the anterior zygapophysis, a process extends outwards and forwards whose extremity is lost in my specimen. Its posterior face is excavated by the lateral fossa above described, This process is probably the diapophysis which supports the rib. The diapophysis springs from the line connecting the zygapophyses, and extends upwards and outwards. Its inferior surface is deeply excavated. Its anterior border sends a lamina upwards, which probably reached the side of the neural spine, but is broken off in my specimen.

The neural spine is thin, but its anterior and posterior borders are thickened and double, the lateral rib-like edges being separated by grooves which expand at the base. The posterior groove continues to a more elevated point than the posterior. Each side of the spine is divided into two shallow wide grooves by a median keel. The apex of the spine is much thickened transversely, its obtuse extremity having the fore and aft and transverse diameters equal.

The pubic bone resembles that of the *Camarasaurus supremus*, but is less robust in all its parts. It is also less extended in antero-posterior width near the proximal extremity.

The femur is remarkable for its slender form. It is a few inches longer than that of the *Camarasaurus supremus*, but is not so robust. The shaft is nearly round and somewhat contracted at the middle, where it is slightly convex backwards. It is slightly curved inwards at the great trochanter. Here the shaft is moderately grooved on the posterior face. This trochanter is only a prominent ledge below the head. The third trochanter is situated a little above the middle of the shaft; it is a prominent obtuse ridge directed backwards. The condyles are extended well posteriorly, and are separated by a deep popliteal groove, which originates on the inferior portion of the shaft. They are also separated anteriorly by a shallow open groove. The external condyle is rather more robust than the internal.

The length of the femur is six feet four inches; the elevation of the dorsal vertebra three feet three inches.

Measurements.		M.
Diameter of dorsal centrum	fore and aft.....	.245
	vertical	.270
	transverse.....	.265

Total elevation of vertebra		1.100
Length of neural spine		.600
Elevation of anterior zygapophyses		.500
Diameter of neural spine	antero-posterior	.160
	transverse (at middle)	.065
	" at summit	.140
Depth of centrum below pneumatic foramen		.120
Fore and aft diameter of pneumatic foramen		.080
Length of pubic bone		1.060
Thickness of stoutest extremity		.140
Length of femur		1.524
Transverse extent of proximal end		.420
" " " condyles		.320
Diameter of middle of shaft		.220
Distance from head to third trochanter		.665
Diameter of head (compressed)		.260

AMPHICŒLIAS LATUS Cope.

Paleontological Bulletin, No. 27, p. 4.

Of the wonderful fauna of the Dakota epoch of the Rocky Mountains the *Camarasaurus supremus* was preëminent in general proportions, the *Amphicœlias altus* was the tallest, and the saurian now to be described, was the most robust. It is represented in Mr. Lucas' collection by a right femur and four caudal vertebræ which are in good preservation. They reveal the existence of another saurian of huge dimensions, and of great mass in proportion to its height.

The caudal vertebræ are apparently from the anterior part of the series. They are all strongly bi-concave; the anterior face more so than the posterior. They all possess diapophyses of depressed form, which take their origin below the base of the neural arch. The centra are short in antero-posterior diameter, and do not present lateral angles. They are composed of not very dense osseous tissue. The anterior zygapophyses are rather elongate, and their articular faces are directed steeply inwards. They are received by corresponding shallow excavations, one on each side of the posterior base of the neural spine. The neural spines are compressed and straight, and become very robust towards the apex.

The femur is extraordinarily robust. The great trochanter is low, but the shaft is widest where it expands outward. The third trochanter is a ridge, is above the middle, and is short and little prominent. It is on the inner edge of the posterior aspect of the shaft, and looks backwards and inwards. The shaft in its present state is compressed so as to reduce the antero-posterior diameter. It is not however crushed or cracked. The condyles have much greater transverse than antero-posterior extent. They are moderately produced backward, and are separated by a deep inter-condylar groove, while the anterior trochlear groove is wide and well marked. The inner condyle is narrowed posteriorly, while the external one is obtuse and robust.

The articular extremity is marked with irregular pits as in *Dystrophæus* and *Cetiosaurus*.

Measurements.		M.
Diameter of anterior caudal vertebra	fore and aft...	.150
	vertical.....	.200
	transverse.....	.260
Elevation to zygapophyses of the same.....		.250
Total elevation of the same.....		.480
Length of femur.....		1.400
Proximal diameter of femur	fore and aft.....	.165
	transverse	.410
Distal diameter of femur	fore and aft.....	.360
	transverse.....	.450
Diameter of middle of shaft of femur.....		.280

The caudal vertebræ of this species are much more deeply biconcave than those of the *Camarasaurus supremus;* they also differ in their relatively and absolutely greater breadth of centrum.

TICHOSTEUS Cope.

Paleontological Bulletin No. 26, p. 194 (Published November 21st, 1877).

Tichosteus lucasanus Cope.

Loc. cit.

SYMPHYROPHUS Cope.

Vertebral centra moderately elongate, slightly amphicœlous, and composed of uniformly and moderately dense osseous tissue. A narrow deep fossa in the floor of the neural canal. Neural arch coösified to centrum, with a lateral shallow fossa at its base. Neither costal articulation nor process on the centrum.

The coösification of the neural arch of this genus distinguishes it from the few amphicœlous crocodilian genera known from North America, and the fossa at its base is so shallow as to separate it from sauria of the *Pneumatarthrus* and *Ornithopsis* type.

Symphyrophus musculosus Cope.

A vertebra of this species is strongly concave laterally and distinctly so inferiorly. The anterior articular facets plane, the posterior slightly concave. The superficial layer of bone is dense and smooth, excepting near the edges of the articular surfaces, where it is rugose. The rugosity is arranged in a line within the articular faces, and consists of numerous small irregular pits and grooves which inosculate. Near the border the grooves assume a transverse direction. There is a nutritive foramen near the middle of each side of the centrum. There are traces of the neurapophysial suture, showing that the neural arch is distinct in young animals.

Measurements		M.
Diameter of centrum	antero-posterior.....	.032
	vertical.....	.027
	transverse.....	.031

The extremity of a humerus is expanded transversely and displays two unequal condyles, separated by a shallow groove. There are no epicondyles on the external face, but fossæ instead.

Measurements.	M.
Width of distal extremity of humerus	.086
Antero-posterior diameter of larger condyle of the same.	.045

Discovered by Superintendent Lucas near Canyon City, Colorado.

LAELAPS. Cope.

Transac. Amer. Philos. Soc. XIV, 1869, p. 100.

LAELAPS TRIHEDRODON. Cope.

Bulletin U. S. Geol Survey, Terrs. III, p. 805, August 15, 1877.

CAULODON. Cope.

Paleontological Bulletin, No. 26, p. 193, Nov. 21st, 1877.

CAULODON DIVERSIDENS. Cope.

Loc. cit.

CAULODON LEPTOGANUS. Cope.

A second species of the genus *Caulodon* is represented by a single tooth from a locality distant from that from which the *C. diversidens* was derived. Another tooth found with it probably belongs to the same species.

The best preserved tooth possesses the same general form as that of the *C. diversidens*, but the borders of the spoon-shaped crown are thinner and more acute. The convexity of the convex face of the crown does not commence at these edges, but is separated from them by an open shallow groove. There is a median longitudinal swelling at the middle of the length of the concave face. The striking peculiarity of this species is the very small amount of enamel which invests the crown. It is confined to the inner face, and exists there in a thin layer, not more than half as thick as in the *C. diversidens*, which thins out and disappears towards the edges of the crown. Another peculiarity is seen in its absolute smoothness. In *C. diversidens* the enamel, even when polished by use, shows remains of the grooves.

Measurements.		M.
Diameter of crown at base	fore and aft	.015
	transverse	.019
Diameter of crown at middle	fore and aft	.010
	transverse	.021

Found by Superintendent Lucas near Canyon City, Colorado.

COMPSEMYS. Leidy.

COMPSEMYS PLICATULUS Cope.

Paleontological Bulletin, No. 26, p. 195.

EXPLANATIONS OF THE FIGURES will be found at the end of this volume.

On the Palæozoic Rocks of Lehigh and Northampton Counties, Pennsylvania.

By Frederick Prime, Jr., Professor of Metallurgy at Lafayette College, Easton.

(*Read before the American Philosophical Society, December* 21, 1877.)

The Palæozoic rocks of Lehigh and Northampton counties are:

The Potsdam Sandstone (No. I).

The Magnesian or Auroral Limestone (No. II).

The Trenton Limestone (No. II).

The Utica Shale (No. III).

The Hudson River or Matinal Slate (No. III).

The Potsdam sandstone is first found in the outlying peninsula of the South Mountains, known as Lock Ridge, where it occurs on the north-west flank of the hill and undoubtedly has a north-west dip, those dips observed to the south-east being due to a sinking down of the rock at its exposure, where the underlying gneiss has been removed. It next occurs in two small patches on the northern flank of the main range of the South Mountain near Macungie (formerly Millerstown). A small patch of it is also found associated with the gneiss, where the latter crops out through the limestone in the gorge of the Little Lehigh Creek at Jerusalem Church, two miles north-west of Emaus. But it is first seen to any great extent along the north flank of the main range just south of Emaus, where its occurrence is constant, but of varying thickness, and continues for a distance of four and a half miles, after which it can no longer be traced.

It occurs again at the ridge of the South Mountain, close to Allentown, which forms the southern barrier of the Lehigh River, between Allentown and Bethlehem, where the sandstone is about twenty-five feet thick and extends with a few intervals (where it has been cut out by the river) the entire distance between these two places. It also extends across the Lehigh and forms the capping rock of a portion of the gneiss just east of Allentown and north of the Lehigh. The contact between the gneiss and sandstone is distinctly seen about two miles east of Allentown on the Lehigh Valley Railroad track.

The very lowest beds of the Potsdam sandstone are actual pudding-stones, containing pebbles the size of a man's fist and larger, and fragments of red, unaltered orthoclase. The upper beds are composed of a hard, compact quartzite containing greater or less quantities of feldspar nodules, which weather out and impart to the rock a pock-marked appearance. When first quarried the color of this quartzite is blue to bluish-gray, which on exposure soon changes to a dark reddish-brown, due to the oxidation of the ferrous oxide it contains. The change from a pudding-stone to a compact quartzite in the sandstone shows that there has been a gradual

sinking of the earth's crust and an increase in the depth of the sea, thus preparing the way for the subsequent deposition of the limestone.

The Potsdam sandstone often, as elsewhere, contains *Scolithus*.

Next above the Potsdam sandstone occur hydromica slates, which Rogers has called the Upper Primal Slates, but which really form a portion of the No. II limestone, and gradually pass into this. They overlie the Potsdam conformably and are far more persistent in their occurrence, continuing with few intervals the entire distance from the western boundary of Lehigh county to the Delaware River. They lie along the north flank of the South Mountain and overlie the Potsdam conformably wherever this is visible. They are of great economic importance as carrying the lowest range of brown hematite iron ores, to be mentioned later.

These slates are composed in great part of the mineral damourite and occur of a pink, gray, white, and yellow color. When exposed to the weather they very rapidly decompose to soft unctuous plastic clays in a few days, and some of these will in time probably become valuable in the manufacture of coarse kinds of pottery. Generally they contain more or less of the carbonates of lime and magnesia and silica mixed with the damourite.* Hydromica slate also occurs the greater portion of the distance from the western boundary of Lehigh county to the Delaware River, at the junction of the No. II limestones with the No. III slates, here also carrying brown hematite ores in extensive deposits.

It also occurs intercalated in the limestone, forming layers from the thickness of a sheet of paper to several feet, and these layers are innumerable. Their existence has been seen both in rock outcrops as well as in wells which have been sunk.

The clay to which the hydromica slate decomposes is generally of a white color, although sometimes brown from the presence of hydrated ferric oxide. Analyses would seem to show that the clay contains rather less potash than the undecomposed rock.

Overlying the hydromica slates, and conformable with these and the Potsdam sandstone, is the No. II or Magnesian limestone (Auroral of Rogers), which extends as a great mass varying from six to seven and a quarter miles in width. At four points gneiss crops out through the limestone. These are at Chestnut Hill north of Easton, at a hill two miles north of Bethlehem, the gneiss ridge north of the Lehigh, between Allentown and Bethlehem, and at Jerusalem Church, two miles north of Emaus. Otherwise its continuity is unbroken.

In its lower beds the limestone contains large quantities of chert, forming nodular masses of very various sizes and usually having their longest axes conformable to the bedding of the enclosing rock. This chert occurs in the manner described by Safford† as characteristic of the Knox dolomite of Tennessee. It disappears, however, in the upper strata.

* Report of Progress for 1874 of Lehigh Dist. Geol. Survey of Pennsylvania, p. 12.

† See *Geology of Tennessee*, by Safford, p. 215, 218.

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The limestone varies from a blackish-blue to dove color, being for the most part compact to semi-crystalline, while there are occasionally shaly beds. In composition it varies much, often approaching a true dolomite, again a pure limestone. But from the isolated analyses made it would seem as if the percentage of magnesia was less in the upper beds than the lower ones. The limestone is always siliceous, often very much so, and hence much care is now being taken by many of the iron-masters in selecting beds of it, as a flux in their furnaces, which are low in silica, so as to be suitable for smelting the iron ores of the Great Valley and New Jersey, which are also high in silica. It often contains minute grains of pyrite disseminated through it, which weather out on exposure, leaving minute cavities behind. Numerous analyses have shown the presence of ferrous carbonate varying in amount from 0.538 to 1.305 per cent.

A peculiarity of the limestone is that it is often brecciated, the fragments being composed *exclusively of limestone*, cemented together by calcite or dolomite. The brecciated appearance is rarely visible on fresh fracture, being usually brought to view by weathering. When seen in place it will usually be found that one or more brecciated beds occur between two others which do not exhibit this peculiarity. As the beds of the No. II limestone have been much disturbed by the force which elevated the South Mountain range, the probable explanation of this brecciation is that a very hard, unyielding bed occurs between two more pliable ones; that these, when subjected to the lateral thrust of the uprising mass of the South Mountains, have conformed themselves to the folds of the strata, while the harder one, being unable to do this, has been fractured and *re-cemented in situ* by the percolation of calcareous waters.

Some observers have supposed that the No. II formation is actually composed of two limestones, the lower one belonging to the Huronian, the upper to the Calciferous; and patches of the latter are supposed to overlie the former. The upper limestone (according to these observers) having been formed from the lower, the brecciated limestones are adduced as evidences of upheaval and shore action.

The explanation I have offered of the formation of the brecciated limestone is both more in accordance with the facts observed and with the generally accepted view of the deep-sea formation of limestone than the hypothesis above stated; for the brecciated limestones are as common near the base of the series as the top.

Besides the genus *Monocraterion* found in the Lehigh county limestone belongs to the same family as *Scolithus*, and is therefore no greater proof of age than the latter; and it occurs in but one locality close to the top of No. II, having not more than fifty to one hundred feet from the overlying Calciferous and Trenton.

The fossils thus far found in the No. II limestone do not number a dozen specimens, and have been found in but four localities. At Helfrich's Spring, about two and a half miles north of Allentown, the Jordan makes a great bend around a limestone hill, and, by an underground passage of

a portion of its water, has excavated a cave a short distance into it. At the west end of the hill, near the small opening where that portion of the creek forming the spring disappears, there occurs a new species of Monocraterion, as yet undescribed. Of this half a dozen casts have been found; but all efforts to discover the fossil itself have been hitherto unsuccessful. This discovery is the more interesting as the genus *Monocraterion* has hitherto only been known to occur in Sweden.

About half a mile north-east of this five or six specimens of a lingula were found in John Schadt's quarry, but it is impossible to determine its species. About half a mile west of Helfrich's Spring a single specimen of an orthoceratite was found close to the Jordan, just north of Scherer's Tavern, but so imperfect that its species is undeterminable. Finally a specimen of Euomphalus was found on Nero Peters' farm, two miles east of Ballietsville.

Not a single fossil has been thus far found in the No. II limestone of Northampton county.

The No. II limestone, like the Magnesian limestone of the Mississippi Valley, is exceedingly soluble. Streams constantly disappear in the ground, forsaking their original beds except when the volume of water is too great to be carried off by the subterranean channels, and reappearing again as springs at greater or less distances. The effects due to this solution of the limestone are very great. Not only are small sink-holes very common, but beds are found often much contorted locally in a manner which can only be explained by supposing them to have dropped down by their own weight into caverns excavated by the water beneath them. Possibly also the contortion of the hydromica beds as developed in the brown hematite mines at the junction of the limestone with the No. III slates is due to the same action, rendered more prominent by the passage of streams from the slate to the limestone, where the solving action could begin. The different beds too are soluble in very different degrees; some apparently yield at once to the eroding action of water, while others afford a resistance to this operation for reasons as yet unknown, but which are probably rather mechanical or physical than chemical. Knowing as we do so little as to the conditions under which the different layers of limestone, almost or quite identical in composition, were formed, we can only speculate that those layers which resisted erosion were more compact, hard, and dense, perhaps more metamorphosed by a subsequent crystallization than the others, while we actually have no facts on which to base such theories. No better illustration of the darkness amidst which geologists are seeking light can be given than by stating that we are in complete ignorance of the causes which produce different layers of limestone, almost identical in composition, the one above the other. We can explain alternations of shale, sandstone, and limestone by changes in depth of the sea in which they were formed; but such an explanation does not hold good where the same rock continued to be formed. Why should the sediment, whether chemical or mechanical, have formed a continuous layer an inch to several

feet in thickness, and then a break in continuity have occurred, to be succeeded by another layer of the same material?

While the greater portion of the limestone has in all probability been formed in deep water, we have one instance in a quarry in Uhlersville on the Delaware where it must have been formed as a beach, since we find here distinct traces of ripple marks along the entire face of the quarry, some sixty feet high and fifty feet deep, the strata being tilted nearly vertically.

It has been generally supposed that the limestone dips almost universally southward; and while this view holds good for Northampton county, except at the junction of No. II with the No. III slates and along the north flank of the South Mountains, it is not the case in Lehigh county; for here we find north-west dips, more especially along an axis which is prolonged some distance into Northampton county, a short distance above Catasauqua.

As a general thing the limestones pass conformably under the No. III slates, and the few exceptions where the slates dip towards the limestones, and the latter away from the slates can readily be explained by an overturning of the beds towards the south, by which means as in the slate quarry close to and south of Ironton the slate apparently passes conformably below the limestone.

Overlying the No. II limestone occurs the Trenton limestone which is more fossiliferous and contains such characteristic fossils as *Chætetes lycoperdon* and *Orthis pectinella* as well as the stems of an encrinite. It was first found about a mile south of Ironton in Lehigh county, then at intervals between Bath and Martins Creek in Northampton county; but all attempts to trace it as a continuous formation have thus far been unsuccessful owing to the lack of outcrops. It occurs most extensively at Martins Creek on the Delaware, at a point a little south of the cotton mill, and is there as elsewhere apparently conformable with the underlying Magnesian limestone.

This limestone resembles in appearance the No. II, being however more compact and not at all crystalline and of a gray black color.

There has been no apparent sudden break between the two, but the transition has been a gradual one. This was to be expected if the subsidence of the sea-bottom was steady and slow. An examination of the beds between Ironton in Lehigh county and the Delaware River, as close to the junction of the limestone and slate as possible, has shown that the limestone for the entire distance is more or less of a hydraulic one, due to the greater proportion of alumina which it contains. This also was to be expected if the subsidence continued. as signalling an approach to the era of slate-formation and open sea deposition. These limestones are utilized on the Lehigh river in the manufacture of hydraulic cements and lately Portland cement has been made at the Copley Cement Works, which is said to be nearly or quite equal to the imported. Careful search and the demand for it will no doubt cause this variety of the limestone to be explored at various other points in the two counties, and will in time render us independent of the cement now sent from the Hudson River. The lime-

stone is of a dull, earthy appearance, entirely free from any crystalline texture and of a dark grey color.

Before closing our discussion of the limestone it is necessary to speak of the large and numerous deposits of brown hematite iron-ore which occur in it, and which form the main support of the extensive iron furnaces of the Lehigh and Schuylkill Valleys.

The brown hematite iron-ore occurs almost exclusively in two irregular lines of deposition; the one along the northern flank of the South Mountain Range, the other at or near the junction of the No. II limestone with the No. III slates. A few other localities occur, at which the ore is found, but these are insignificant in number compared to the two lines mentioned. Along both these lines the ore is always found either in hydromica slate, or resting on limestone very greatly impregnated with damourite; the same is true elsewhere whenever the brown hematite is found *in loco originali*. Some deposits are however found which have evidently been pockets or cavities in the limestone into which the masses of limonite have been forced together with gravel and clay during the Drift Period. Leaving these out of consideration as of minor importance, let us consider briefly those iron-ore deposits which occur in place. It is at once evident that like the rocks with which they are associated they are of secondary origin, and have been derived from still older formations. The occurrence of the brown hematites with silica, alumina, lime, magnesia, and the alkalies, more especially potash, points to their having been derived from Archæan rocks containing orthoclase and either hornblende or pyroxene. From the decomposition of these three minerals we are able to derive all the oxides above mentioned including the iron which was without any doubt derived in great part from the decomposition of ferrous siliciate present in the hornblende and pyroxene, while a portion of the iron may have been derived from iron pyrites, although this supposition is entirely unnecessary. It is extremely improbable that the brown-hematite was derived from the per-oxidation and hydration of magnetic iron ore, when we recall the great resistance which the latter offers to chemical change of any kind when exposed to the action of air and water, and its unaltered condition and fresh, bright appearance in rivers and on the seashore. But the question as to how the brown hematite got into its present condition and whether it was deposited cotemporaneously with the rocks containing it, or subsequently to these, is still an enigma and various theories have been offered in explanation. For a resumé of some of these hypotheses reference may be made to a recent article by Prof. J. D. Dana, in Vol. XIV, III series Am. Jour. Sci. and Arts, p. 136. The almost entire freedom of the hydromica slate, when fresh, in Lehigh and Northampton counties from ferruginous minerals will prevent our having recourse to pyrite, pyrrhotite, chlorite, garnet, mica and staurolite, which Prof. Dana says occurs in the hydromica region of Connecticut. Hence we must have recourse to other sources. It seems most doubtful that the mineral, from which the brown hematites were derived, was deposited cotemporaneously with the hydromica slates in the district under discussion, since we

find the ore often passing through the slate or clay obliquely and intersecting the bedding. It is more probable that the ore was conveyed to its present position by infiltration subsequent to the formation of the hydromica slates. Whence was it derived? I have already stated that the limestone contains varying proportion of ferrous carbonate and of pyrite and when we consider the enormous erosion which the limestone has undergone, the wonder is not that the deposits of iron ore should be so great, but rather that they should be so small. The ferrous carbonate and the pyrite oxidised to ferrous sulphate being both soluble in water, the former when the water contained carbon di-oxide, the waters would naturally carry these salts in solution until they came in contact with precipitating agents such as the alkaline silicates which the hydromica slates carry. These last became converted to carbonates and sulphates, leaving the iron behind, either directly as hydrated ferric oxide, or possibly as ferrous silicates which became later decomposed by the action of ærated water to hydrated ferric oxide and free silica, which latter we now find so universally associated with the brown hematites as quartz. Whatever the origin of these ores may have been, one thing is evident, *viz.*, that there is some genetic relation between the brown hematites and the hydromica slates, as evidenced by the almost universal occurrence of the ore in the slate, extending all the way from Vermont to East Tennessee through the Great Valley as well as in the interior valleys of Pennsylvania where the No. II limestones occur.

It is well here to emphasize the fact that these brown hematite ores all belong to the Lower Silurian limestone formation, since, in 1873, Dr. Sterry Hunt after a cursory examination of Ziegler's Mine in Berks County, situated at the junction of the No. II limestone and the No. III slates, made the mistake, in a paper on "The Decay of Crystalline Rocks" before the National Academy of Science, of supposing that the hydromica slates belonged to the Huronian Period. A mistake into which so eminent an observer as himself would never have fallen had he been better acquainted with the region.

At intervals along the junction of the limestones and slates there occurs a black carbonaceous shale, often decomposed to black or dark blue clay, which I have supposed to be the representative of the Utica shales. It consists of a very carbonaceous hydromica slate (containing damourite), without any fossils and may not belong to the Utica Period at all. In no instance has it been found more than one to twelve feet thick, but it sometimes carries pyrite from which a portion of the iron ores, just mentioned, may have been derived. These shales are of no economic importance.

Overlying these come the No. III, Hudson River or Matinal Slates, which extend into the Kittatinny Mountains. A large portion of these slates are extremely useful for roofing and other household purposes, and extensive quarries have been opened at various points for the purpose of extracting them, as, however, they have been but very slightly examined, during the progress of the present Geological Survey of the State, I shall defer a more detailed description of them to some future time.

Remarks on Professor Prime's Paper.

By Persifor Frazer, Jr.

(*Read before the American Philosophical Society, December* 21, 1877.)

The paper of Professor Prime is exceptionally interesting to me because similar, though (as I apprehend him) not identical and perhaps not cōeval, deposits of limonite occur in many parts of the district which I have been studying for four years, and which includes Franklin, Adams, Cumberland, York and Lancaster Counties. The two lines of limonite banks to which Professor Prime refers are also found there, and apparently in analogous position, viz: at the upper and under surfaces of the calciferous formation (but not usually in the latter position when there is no representation of the slates). Besides these two horizons of ore (if the term horizon may be applied to local deposits, in many cases principally produced long after the strata on the borders of which they lie) there are at least several others which cannot be referred either to the top or the bottom of the formation, but at various positions between the two. On the general maps accompanying my report of progress for 1874, there appear to be four or five such lines besides two principal ones nearly converging near Hanover, York County.

This rough conformity of the limonite to the limits of the limestone rock indicates a connection between the two more close than can be attributed to accident.

It has been often repeated before that the greatest exhibitions of iron ore of this character are almost invariably found directly in contact with the limestone, and one would naturally suppose that the cause was to be sought either in the action of one upon the other or in conditions which resulted in evolving both of them. It is true that the position of the clays in all these banks (including the larger ones just referred to), forbids the supposition that the deposits have been entirely produced by infiltration from other points, for, as Dr. Hunt has long ago conclusively shown, there are strings and lenticular masses of iron hydrates, &c., which lie within, and, conformably to the edges of the kaolinized slates, repeating all the convolutions of the latter, and showing other unmistakable signs of contemporaneous history.

Nevertheless, the alteration of the ferriferous minerals which were the origin of these limonite nests has apparently gone forward more rapidly when there was an abundance of carbonate of lime present, than when this rock was represented by the argillaceous and schistose members of the series to which it gives its name.

As to the amount of material necessary to produce all these beds, it might have been much more than furnished by the Pyrite alone, of which we know the former existence by the countless pits and casts which completely permeate the strata; as I endeavored to show several years ago.

In opposition to the chemical hypothesis of the origin of these limonites, it is only just to cite the occurrence at Bull's Run (five miles south of Wrightsville, York County), amongst the calciferous slate, and even the limestone itself, of unusually large Pyrite crystals still in a perfect state of preservation, though under conditions very favorable to metamorphosis. Perhaps the generally gentler dip of the strata at that point protected the pyritiferous layers from the percolation; or perhaps some other cause may account for it; or perhaps the whole idea of the chemical production of limonite is erroneous, though in its support may be mentioned the results of the following experiments:

About 20 grams of crystallized ferrous sulphate were dissolved in 100 c c. of water.

About 50 grams of crystalline limestone were then ground up into fine powder, and placed in a glass stoppered bottle, into which 50 c c. of water was poured.

Ten c c. of sulphuric acid of density about 1.7 were then added, and the contents agitated. After the effervescence had subsided, the iron solution was poured into the same beaker, and the contents again strongly agitated.

After the subsidence of the powdered carbonate of lime, and upon it the light precipitate of calcium sulphate, the liquid was left undisturbed. It gave at first a feeble acid reaction, but later became quite neutral.

From time to time in the course of 24 hours the bottle was shaken, and the sediment again allowed to subside.

A light film of iron hydrate began to be perceptible in a few moments after the first shaking, and was quite perceptible both as a layer above the calcium sulphate, and as a ring which formed around the interior of the flask at the surface of the contained liquid.

This can be observed in the flask which I have brought here, the yellowish brown ring occurring at about the height of the upper surface of 150 c c in this bottle.

It suggested itself that possibly this action might result from the oxidation of the iron solution and precipitation at the surface. To test this the bottle containing the substances above described, was placed in a beaker of about 1.5 liter capacity, and water was carefully poured into the latter so as to overflow and finally submerge the lip of the bottle about 3 cm below its surface, the solution from this time being left undisturbed.

In the course of 24 hours or less there was a very copious flocculent precipitate of iron hydrate in the bottom of the beaker, and on the sloping neck of the bottle while the surface of the fluid was covered with an iridescent film like that on many natural chalybeate waters.

This experiment seemed to show that in presence of limestone the neutral sulphate of iron is readily decomposed in contact with atmospheric air, and the sediment precipitated as a flocculent mass from the upper surface of the fluid.

The reaction of the solution was entirely neutral.

Very little of the precipitate was observed upon the surface of the powder, the rapidity of the chemical change being proportional to the extent of surface in contact with air, and probably to the strength of the solution. The fact that the fluid exhibited no signs of acid reaction is sufficient proof that for every molecule of iron hydrate thus set free one atom of calcium took its place as a sulphate.

To test whether this exchange was effected by the intermediate production of iron bicarbonate, and the decomposition of this at its contact with air, the fluid was examined for carbonates in solution, but none were detected.

It seems probable then that in presence of bodies of limestone and free oxygen, iron sulphate is decomposed and its base precipitated at the expense of the calcium in the limestone.

Another experiment was tried to ascertain the amount of diffusibility of this solution of iron sulphate.

Another beaker of about 1 liter capacity was placed by the side of the first, and filled with water. A piece of large French filtering paper having been rolled up, the ends were immersed in the respective beakers. After standing for 24 hours with the fluid in the beakers at about the same level, the contents of the beaker last employed were tested without finding a trace of iron in it.

A gum tube of about 30 mm. internal cross-sections was then bent, filled with water, the ends stopped by the thumbs, and placed beneath the surface of liquid in the respective beakers.

After two hours of this syphon connection, the contents of the second beaker were again tested without finding any traces of iron.*

In connection with this subject several years ago I sought to explain the chemical reactions involved in the production of limonite by means of limestone in the following four chemical equations from pyrite (though I never have considered it necessary to assume that pyrite was the only ferriferous mineral concerned in this production).

$$\mathrm{Fe\,S_2 + O_7 + H_2O} \quad \left[\begin{array}{l}\text{in presence of oxygen, water and}\\ \text{limestone.}\quad \mathrm{O + H_2O + CaCO_3}\end{array}\right]$$

a. By taking up oxygen and one molecule of H_2O $\}$ $= \mathrm{FeSO_4 + H_2SO_4}$ [Ox, Aq. limestone.]

b. By decomposing 1 molecule of $CaCO_3$ $\}$ $= \mathrm{FeSO_4 + CaSO_4 + CO_2 + H_2O}$ [Ox, Aq. limestone.]

c. By decomposing one molecule of $CaCO_3$ and absorbing 1 molecule of H_2O $\}$ $= \mathrm{(CaSO_4)_2 + H_2Fe\,CO_4}$ [Ox, Aq. limestone.]

d. By oxidation in air (twice the previous) $\}$ $= \mathrm{(CaSO_4)_4 + H_xFe_2O_y + (CO_2)_2}$ [Ox, Aq. limestone.]

It now appears however, that the intermediate stage of iron bicarbonate is not necessary, but that the oxide may be directly produced after the hy-

*The same experiment was tried, after the beakers had been connected by a column of water for over a week, with the same result.

droxidation of the pyrite by reaction with limestone in presence of air thus:

$$(H_2O)_3 + O + (FeSO_4)_2 + (CaCO_3)_2 = (CaSO_4)_2 + H_6Fe_2O_6 + (CO_2)_2.$$

In the region which I have studied, it seems to be as difficult to define any horizon or horizons of hydromica slate as to define an horizon of moisture, or of hard and soft rock. Hydromica slate in the counties before named occurs at any horizon, and in all possible relative positions to the limestone. So far as I have been able to judge the relations of these strata to the limonite, they are twofold: 1st, as a carrier of the pyrites, and perhaps other iron bearing minerals, which by their separation from the other constituents have been washed down and collected in the impervious strata *actually* beneath them. 2d, as the material out of which the impervious clays themselves have been produced.

As to the age of these hydromicas, they appear to be represented in the rocks of several ages. There are some which seem to be intercalated with, and therefore of the same age as the limestone itself.

Some are found geologically beneath the limestone and intercalated among the chlorites, quartzites, and orthofelsites of the South Mountain group.

Crystallography in Sculpture.

By Persifor Frazer, Jr.

(*Read before the American Philosophical Society, January* 4, 1878.)

Mr. Spring an artist and a modeler in clay has conceived the ingenious idea of making the human head out of a number of plane surfaces of different area, and he designs these models, less to aid in teaching anatomy than to aid in teaching sculpture.

There are some fifty planes more or less represented on the small models such as this here shown, and of course it is of value to be able to designate each of them by some succinct and comprehensive notation.

It was suggested to Mr. Spring to apply to crystallography for this purpose.

The head here represented is of a high Caucasian type, unless I am deceived, and the symmetry of the features is as striking as their representation by planes is novel.

Of course since a plane represents a certain portion of such variable parts as the flesh, lips, ear, &c., no crystallographic formula would represent the same feature on each of two twins, nor would it represent the same individual in different frames of mind, and states of physical condition, viz.: angry; sentimental; after dinner; after sleep, &c.; nevertheless, a sort of rough approximation to his mean condition will enable if

not every man to get his own crystallographic formula, at least that of his race to be expressed.

It must be borne in mind too that the planes here shown are not absolutely correct, but simply an arbitrary series laid on by that most difficult of all persons to calculate exactitudes from — a skillful artist.

In spite of this (and to give the names rather of the things each individual most nearly resembles than what it actually is, and thus aid the student in deriving and placing them), the following attempt was made :

Even with the most symmetrical human face a slight consideration will convince one that the Triclinic System or the System of Pinacoids is the only one which will serve to represent all the planes; nevertheless the zone of macrodemes require a monoclinic habit : and even this fails in many cases owing to a lack of parallel pairs : so that one is obliged to introduce the somewhat crystallographically confusing notion of a single plane.

Yet the general parameter relations of such a plane and the position which it occupies above, below ; in front, in rear ; right, or left ; being indicated by P·, P., ·P, .P for the front (when necessary, adding for the rear P′, P,, ′P, ,P) its actual position on the model may be sufficiently well known.

Not that this is not found in nature for some calamine and tourmalines have the peculiarity of being asymmetrical or hemimorphic; and instances of a lower termination of one basal plane and an upper one of a pyramid are not rare.

Assuming the upper trapezoid on the model to be the basal plane or 0P of some triclinic prototype, the following represent some of the principal forms represented :

*m $\bar{P}$ ∞	upper forehead.	Zone of Macrodomes.
†n $\bar{P}$ ∞	middle frontal.	
†q $\bar{P}$ ∞	bridge of nose.	
r $\bar{P}$ ∞	middle of upper lip.	
s $\bar{P}$ ∞	upper chin.	
t $\bar{P}$ ∞	middle chin.	
u $\bar{P}$ ∞	under chin.	

0 $\bar{P}$ Top of head and plane of nostrils.... Basal Pinacoid.
∞ $\bar{P}$ ∞ Front and back of neck.....Macropinacoid.
∞ $\bar{P}$ ∞ Side planes of neck.....Brachypinacoid.

m·P·	upper skull (4 planes).	Pyramids.
n·P·	upper skull (4 planes).	
q·P·	side frontals and lower occiput (4 planes).	
r·P·	side occiput and middle cheeks (4 planes).	
t·P·	side skull front and above ears (2 planes).	
y·P·	cheeks beside nose (2 planes).	

* Represented also in two occipital planes, 3 in all.
† Represented also in one occipital plane, 2 in all.

∞'P' { Four of neck planes..... / also cheek by back jaw and posterior skull by / ear..... } Prism.

Of course it is understood that m, n, t, r, &c., are simply coefficients by means of which to derive all the forms to which they refer in parameter values from some typical P whose parameter values must be assumed as normal.

The whole object is merely to enable the sculptor to give each plane a name and not entirely an arbitrary one.

On a Series of Chemical Analysis of Siluro-Cambrian Limestone Beds in Cumberland County, Pennsylvania.

By J. P. Lesley.

(*Read before the American Philosophical Society, December* 21, 1877.)

The mixture of magnesia with lime in dolomite rocks has always stimulated and baffled geological speculation, and given birth to opposite hypotheses; some of them, such as that of the issue of magnesium vapors from the interior of the earth, absurd enough; others, such as that recently propounded by Mr. W. L. Green, British Minister at Honolulu, who derives the magnesia from olivine in lava, very suggestive of truth.

I have long felt that no sound basis for speculation had been secured so long as the collection of facts consists merely of analyses of sporadic specimens of limestone and dolomite rocks. I therefore directed Mr. R. H. Sanders, of the Pennsylvania Geological Survey, to make a careful section of the Siluro-Cambrian strata exposed for a quarter of a mile along the west bank of the Susquehanna River, opposite Harrisburg, both by the deep cuttings of the North Pennsylvania Railroad, and by quarries. This was done in connection with his field work in Cumberland County.

Mr. Joseph Hartshorne was also directed to take duplicate samples from every stratum, thick or thin, in this section; one at railway grade, and the other at the top of the exposure (sometimes 30′ high); to analyse them in the laboratory of the Survey at Harrisburg. This he has done, and is still doing, devoting his entire time and attention to the selection of the samples in *situ*, and their determination in the laboratory. In all cases of doubt the analyses have been duplicated and sometimes triplicated; and a report of all analyses as fast as made is forwarded to headquarters.

Of the whole conformable series of beds numbered from the topmost (dipping about 30° to the south) No. 1 down to No 98, Mr. Hartshorne has as yet only analysed from No. 1 to No. 46. But the generalization which

the series foreshadows is so interesting and novel that I venture to present it to the notice of the Society, and its correspondents.

Mr. Sanders' report of the beds is as follows:

No. of bed.	Thickness in feet and inches.	Lithological character.
1	3′ 0″	Limestone, light gray.
2	2′ 9″	" gray.
3	3′ 6″	" dark blue.
4	4′ 6″	" dark gray.
5	8′ 1″	" dark blue, with numerous lenses of flint.
6	2′ 0″	" dark blue.
7	0′ 9″	" light blue.
8	2′ 3″	" light blue; seams of calcite; fault of 13″.
9	2′ 8″	" dark blue.
10	13′ 8″	" dark gray; some calcite.
11	5′ 7″	" dark gray; calcite.
12	3′ 8″	" gray.
13	12′ 8″	" gray.
14	4′ 4″	" dark gray.
15	2′ 9″	" dark blue.
16	2′ 8″	" dark blue.
17	1′ 0″	" light gray.
18	1′ 1″	" light gray; with calcite.
19	2′ 0″	" light gray.
20	1′ 2″	" dark gray.
21	2′ 0″	" dark blue; with some flint.
22	1′ 4″	" light gray; with some flint.
23	6′ 11″	" dark blue; with streaks of flesh colored.
24	0′ 7″	" light gray; with a great deal of calcite.
25	0′ 9″	" dark blue.
26	1′ 11″	" dark blue.
27	6′ 5″	" dark blue; seams of calcite.
28	4′ 1″	" light gray.
29	2′ 7″	" dark blue.
30	1′ 0″	" light gray; large amount of calcite.
31	3′ 2″	" dark blue; few veins of calcite.
32	6′ 8″	" dark blue; few veins of calcite.
33	0′ 10″	" light gray.
34	1′ 7″	" dark gray; calcite.
35	0′ 4″	" dark blue; with white spots.
36	4′ 6″	" dark blue.
37	0′ 10″	" light gray; with seams of calcite.
38	4′ 3″	" dark blue.
39	3′ 2″	" light gray; seams of calcite.
40	1′ 2″	" dark gray; seams of calcite.
41	2′ 3″	" bluish black.
42	0′ 3″	" bluish black.
43	3′ 6″	" bluish black; black flint.
44	0′ 10″	" dark gray; with calcite.
45	0′ 5″	" light gray.
46	0′ 2″	" light gray; with calcite.
47	0′ 6″	" light gray; with calcite.
48	1′ 10″	" dark gray; black flint.

No. of bed.	Thickness in feet and inches.	Lithological characters.
49	4′ 0″	" light gray ; seams of calcite.
50	0′ 5″	" light blue.
51	5′ 2″	" dark blue ; few seams of calcite.
52	0′ 11″	" light blue.
53	1′ 0″	" gray ; veins of calcite.
54	1′ 10″	" gray ; veins of calcite.
55	2′ 0″	" light and dark gray.
56	1′ 10″	" light blue.
57	0′ 10″	" light gray ; spots of calcite.
58	2′ 4″	" dark gray ; lenses of flint.
59	5′ 8″	" light gray.
60	6′ 4″	" dark blue ; masses of flint.
61	1′ 9″	" light gray ; seams of calcite.
62	14′ 0″	" dark blue.
63	2′ 10″	" dark gray ; much flint.
64	6′ 6″	" dark blue ; cleavage planes calcite.
65	3′ 8″	" light gray ; full of calcite.
66	4′ 6″	" dark blue ; with calcite.
67	5′ 6″	" gray, with a reddish tinge.
68	3′ 7″	" light gray.
69	5′ 0″	" dark blue, with yellow streaks.
70	2′ 3″	" light gray.
71	1′ 2″	" bluish black.
72	2′ 3″	" light gray ; calcite.
73	3′ 0″	" dark gray.
74	6′ 0″	" dark blue ; some little calcite.
75	5′ 3″	" light gray ; seams of calcite.
76	1′ 9″	" light gray.
77	6 3	" light gr y.
78	7 3	" light gray, part flesh colored.
79	6 8	" dark blue.
80	11 5	" light gray, streaks of flesh colored.
81	1 5	" light gray.
82	5 9	" dark blue.
83	1 5	" light gray.
84	2′ 5″	" dark gray.
85	4′ 9″	" dark blue.
86	5 10	" very dark blue.
87	6 5	" light gray ; full of calcite.
88	17 8	" dark blue.
89	3 9	" dark gray ; some calcite.
90	5 0	" dark gray, and flesh colored.
91	8 9	" dark gray.
92	1 2	" light gray.
93	26 6	" dark gray (several beds all alike).
94	5 6	" light gray ; calcite.
95	4 6	" dark gray.
96	11 3	" dark blue.
97	8 0	" dark gray.
98	30′ 4″	" dark gray.
	425′ 9″	

This last and lowest bed visible at the north end of the exposure is calculated by Mr. Sanders to lie 1280 feet above the lowest bed of the whole series of Cambro-silurian limestones, or in other words, 1280′ higher in the Palæozoic system than the Potsdam Sandstone. This calculation is made by projecting curves according to all the observed dips between the north end of exposure, and the edge of the slate country to the north, checked by dips in a series of exposures on the east bank of the river. It is not necessary to go here into a discussion of the existence of a great upthrow fault between the limestones and slates.

The topmost bed, No. 1, of the series is therefore $1280' + 426' = 1706'$ above the Potsdam Sandstone.

The upper limit of the limestones, where they pass conformably beneath the Utica or Hudson River slates, is seen several miles down the river. By projecting dip-curves in the interval Mr. Sanders measures an additional thickness of limestones amounting to 1819 feet.

The total observed thickness of the great limestone formation (No. II of the old Pennsylvania Survey including representatives of Calciferous, Chazy, Birds' eye, Black-river, and Trenton limestones) is 3535′.

The beds selected for examination lie therefore a little below the middle horizon of the mass, and undoubtedly belong to the "Calciferous Limestone Formation" of the New York geologists, the Magnesian Limestone Formation of the Western geologists.

All these beds contain carbonate of magnesia; but while in some of them the percentage of this element is very low, as low as 1% or 2%, it rises in others very high, even to 37%. Some of the beds may therefore be spoken of as pure limestones, and others as true dolomites. The remarkable features however are: 1. That by virtue of some unknown law very few of the beds seem to occupy an intermediate place or exhibit a mixed or moderate character; and 2. That the two extreme types alternate, every other bed being limestone, and every other bed being dolomite.

The astonishing regularity of this law is not so evident to one who merely reads the table of analyses, but unmistakably forces itself upon the attention if the reader converts the table into a diagram. Whether the law rules over the sequence of the whole series of 98 beds is yet to be discovered. Even if it does we cannot safely formulate it as a law determining the distribution of the carbonate of magnesia throughout the 3535 feet of Siluro-cambrian limestones. But such a law, whatever be its restrictions, demands the earnest attention of chemists and geologists.

The following table then gives the percentage of *carbonate of magnesia* in each bed: in column A at railway grade; in column B at the top of the cut, or quarry. Also, the *carbonate of lime*, column C, railway grade, column D, top of cut. Also, *insoluble material*, column E, at grade, column F, at top.

Number of bed.	Carb. Magnesia. A	Carb. Magnesia. B	Carb. Lime. C	Carb. Lime. D	Insol. matters. E	Insol. matters. F
1	36.9	38.3	58.3	57.0	4.6	4.0
2	38.5	3.97	55.6	56.2	5.3	3.8
3	38.1	2.7	56.3	87.6	4.7	8.8
4	1.8	1.9	94.0	97.1	3.8	1.4
5	1.4	0.7	96.4	97.3	1.9	2.1
6a } 6	1.4	1.3	95.5	97.6	1.5	1.0
6b }	3.6	3.7	87.1	87.4	9.7	9.0
7	14.5	7.5*	82.3	87.5*	3.1	3.9*
8	24.8	27.1†	68.3	67.6†	5.5	5.4†
9	8.1	8.2	90.7	90.3	1.9	5.7
10	1.8	1.3	97.6	96.7	1.1	2.2
11	32.4	20.0	66.0	75.9	1.6	2.5
12	2.3	1.9	96.8	97.3	1.2	1.4
13	2.4	11.9	95.8	83.9	1.8	3.4
14	4.4	1.0	92.4	97.3	3.4	1.8
15	1.3	2.0	91.8	97.1	1.1	1.2
16	1.1	33.4	97.7	60.1	1.1	5.9
17	1.2	4.3	97.0	93.5	1.3	2.1
18	30.8	34.5	65.3	62.3	3.5	2.9
19	3.0	0.8	96.4	98.7	0.7	0.5
20	18.5	24.3	76.3	71.5	5.3	4.2
21	3.8	1.6	93.7	97.4	1.9	1.3
22	30.8	28.6	65.3	64.3	3.4	6.5
23	1.6	2.0	94.8	93.1	3.9	4.8
24	23.8	23.6	68.9	68.9	7.4	6.3
25	6.8	6.3	90.0	71.0	3.4	22.9
26	28.5	18.1	63.3	75.7	6.2	5.6
27	6.7	2.0	81.3	94.2	12.0	4.0
28	29.1	31.4	65.0	62.4	5.4	5.4
29	1.1	1.5	98.9	97.9	0.6	0.9
30	27.7	25.1	61.0	64.3	10.9	10.3
31	1.7	1.0	96.7	97.6	1.7	1.8
32	1.6	1.2	97.6	96.3	1.1	1.5
33	18.8	25.7	75.2	67.2	4.7	5.9
34	15.0	3.5	81.6	93.6	2.7	2.8
35	17.0	13.3	79.7	83.0	2.9	2.8
36	8.2	1.6	87.7	98.7	1.6	0.3
37	33.6	37.3	61.5	5.63	4.7	6.1
38	1.7	2.2	96.9	95.8	1.4	1.9
39	35.0	34.8	55.6	57.2	6.9	6.5
40	1.3	1.3	92.8	91.0	1.3	7.9
41	22.5	28.2	73.6	6.55	3.4	4.8
42	2.0		96.2		2.4	
43	1.7	7.6	97.2	90.1	0.7	1.8
44	29.5	27.1	63.4	68.2	6.4	3.6
45	1.9	2.2	94.3	95.3	3.5	2.2
46	33.2	26.9	57.8	66.2	8.0	5.7
*Bed 7	3d analysis	21.7		72.2		6.3
†Bed 8	" "	30.9		63.6		5.1

*†The third analysis was of a sample intermediate between the top and bottom of the exposure.

The percentage of *Carbonate of iron* in these beds runs thus in the samples taken at railway grade : ..... .725 .638 .363

.406	.058	.914	.203	.319	.566	.102
.044	.015	.073	.073	.058	.029	.450
.203	.682	.123	.131	.087	.392	.174
.460	.189	1.189	.290	.696	.058	.219
.363	.110	.885	.653	.580	.479	.725
.479	2.422	.218	.617	.058	.040	1.310
.334	1.438					

and the samples at the top exhibit about the same variations within the same limits, bed 16 showing 1.044 ; bed 39, 1.994 ; bed 41, 1.523 ; bed 44, 1.537 ; bed 46, 1.552, and all the rest falling below one per cent.

The percentage of *Alumina* is extremely low, being *nil* in many of the beds, and .002 .020 .030 .180, rising in four instances to .300 .350 .479 and .600 in the first set of samples, and to .390 in one instance in the other set.

The percentage of *Sulphur* in the first set of samples taken from the bottom of the cuttings is as follows : .... .048 .050 .044

.119	.070	.050	.032	.058	.076
.028	.589	.042	.034	.027	.018
.040	.095	.088	.076	.025	.106
.016	.095	.089	.065	.069	.017
.176	.095	.081	.128	.150	.080
.048	.133	.130	.141	.051	.072
.071	.115	.059	.092	.035	.071
.096	.096	.075			

and in the second set keeps about the same range, but never exceeds .200 except in the *third* (2.50), twenty-seventh (.222), forty-fifth (.307), and thirty-third (.438) beds.

The percentage of *Phosphorus* in the first set is as follows : .....

.006	.008	.003	.013	.006	.trace
.trace	.none	.008	.trace	.006	.014
.006	.015	.008	.003	.trace	.003
.011	.006	.006	.trace	.trace	.trace
.trace	.trace	.trace	.none	.none	.none
.010	.none	.none	.005	.none	.none
.none	.none	.none	.018	.none	.003
.006	.trace	.004	.011	.trace	.trace

the highest being .018.—In the second set three go up to .010, two others to .013, one to .015, one to .017, and one as high as .061.

The percentage of Carbonaceous matter in the first set ranges as follows :

.094	.012	.472	.166	.128
.090	.250	.152	.150	.098
.124	.128	.050	.208	.138
.076	.040	.040	.020	.036
.010	.016	.160	.060	.130
.030	.590	.123	.200	.018
.268	.082	.100	.266	.208
.086	.054	.032	.060	.288
.trace	.174	.trace	.126	.064
.10$\frac{4}{}$	.050			

the highest being .472 and .590.—In the second set the amount of carbonaceous matter rises to .212 (45th bed) .220 (6th *b*) .300 (6th *a*) .450 (28th) .540 (24th).

All attempts to generalize the results must be deferred until the series of analyses shall be completed.

NOTE.—January 30, 1878. The following additional analyses have been received from Mr. Hartshorne. Bed 6 was subdivided into an upper and a lower portion, although no bed plate subdivision *in situ* could be detected ; solid limestone was seen graduating downwards into laminated limestone, almost a slate. The excess of insoluble materials in 6*b*. over 6*a*. shows the cause of the structure :

6*a*.	3.6	4.0	89.9	92.0	5.7	4.1
6*b*.	3.2	4.1	67.2	66.5	26.6	25.3
47	32.4	31.7	60.4	62.0	5.3	5.1
48	3.2	2.9	92.9	95.7	3.0	1.7
49	31.9	23.7	61.4	68.9	5.3	7.2
50	10.0	7.0	84.1	88.7	4.7	3.4
51	1.3	1.2	98.2	97.9	1.2	0.7
52	10.8	13.4	79.8	79.5	8.6	6.9
53	24.2	23.2	66.9	66.1	7.4	9.7
54	2.4	2.3	91.6	91.0	5.9	6.8

[*Continued from page* 16.]

Meteorological Institute of Vienna, October 1 (96, 88); Astronomical Society of Leipsig, September 17 (99); Royal Academy at Munich, July 1 (97); the Wurtemburg Union at Stuttgardt, August 1 (95, 96, 97 and 98, returning also duplicates); the Victoria Institute, September 15 (99); Statistical Society, September 27 (99); and M. M. Barcena, Mexico, September 29 (97, 98, 99).

Letters of envoy were received from the R. Swedish Academy, June, 1877; R. Bavarian Academy, July 1, 1877; and Cambridge Philosophical Society.

Donations for the Library were received from the Imp. Academy of Russia; R. Swedish Academy; R. Danish Society; R. Observatory at Prag; Geological Institute and Anthropological Society at Vienna; the German Geological Society at Berlin; the Societies at Bremen, Giessen, Görlitz, and Stuttgardt; the R. Observatory and R. Academy at Munich; the Vaudoise Society and M. Henri de Saussure, and M. F. W. C. Trafford; the Geograph. and Anthropological Societies, Academy of Medicine, Museum of Natural History, Annales des Mines, Révue Politique and M. Hugo, of Paris; Physical Society at Bordeaux; Natural History Society at Bordeaux; Academy at Brussels; Victoria Institute; R. Geographical, Zoological and Antiquarian Societies, and London Nature; Cambridge Philosophical Society; Canadian Journal, Toronto; Essex Institute; Prof. O. C. Marsh; Penn Monthly; Medical News; American Journal Med. Sciences; Mr. Geo. E. Emory of Lynn, Mass.; Botanical Gazette, Ind.; and the Meteorological Observatory at Mexico.

An obituary notice of the late Vice-President, John Chapman Cresson, was read by Mr. Fraley, followed by remarks and reminiscences by Mr. Roberts.

A communication entitled: "On Land Plants in the Silurian of N. A., and on a Fungus discovered in the Coal Measures of W. Pennsylvania. By Leo Lesquereux," was read by the Secretary.

On motion, the Secretaries were authorized to print the 8° plate, accompanying the memoir, drawn and published in the Proceedings.

Dr. Cresson communicated the analysis of a specimen of coal from Pulaski county, Va., which he exhibited and discussed with other members present.

Prof. Chase announced that at the request of Mr. Hall he had sought and found a harmonic series which exactly adapted itself to the radii of the observed orbits of Deimos and Phobus, to the radius of Mars, and to the centre of oscillation in Mars, and gave the correspondence of the theoretical and observed numbers on the black board.

Permission was given the Secretaries to report their Coalslack advertisement at the next meeting.

Pending nominations 839, 840, 841 and 842 were read, and 839 ballotted for.

On scrutiny of the ballot boxes the election of Mr. W. B. Taylor, of the Patent Office, Washington, D. C., was announced by the Chairman.

Stated Meeting, November 2, 1877.

Present, 16 members.

Vice-President Mr. Price in the Chair.

A letter accepting membership was received from Mr. Wm. B. Taylor, dated Washington, D. C., October 26, 1877.

Letters of acknowledgment were received from the New Zealand Institute, Wellington, September 7, 1877 (Trans. O. S., I to VI; N. S., I to XIV, and XV, i. ii.; Proc. VIII to XVI, except No. 96); from the Lond. Soc. of Antiquaries, October 9, 1877 (99); and the R. S. Edinboro', October 13, 1877 (99).

A letter of envoy was received from the Central Physical Observatory at St. Petersburg, September, 1877.

A letter requesting No. 88 was received from the R. In-

stitution of S. B., dated October 11, 1877. On motion the request was granted.

A letter requesting information concerning the publications of the Society previous to 1876 was received from F. Leypoldt, N. Y.

Donations for the Library were received from the R. S. New S. Wales; Gen. Stone of Cairo; Met. Obs. Dorpat; Soc. at Ulm; Révue Politique; R. Ast. S., and London Nature; Dr. E. Jarvis, Mass.; A. Antiq. S. Worcester, Mass.; Water Department of Philadelphia; Mr. C. W. Hart; Prof. E. D. Cope; Internat. Medical Congress; Mr. S. H. Scudder, and the U. S. Coast Survey.

Prof. Cope exhibited a number of fine teeth and other remains of Triassic vertebrates, found by Mr. Wheatley at his copper mines near Phœnixville, and laid on the table for publication in the Proceedings "Descriptions of extinct Vertebrata from the Permian and Triassic formations of the United States, by E. D. Cope, a part of which was a MSS. record of remarks made by him August 17, 1877. The descriptions in the paper apply to the following new names:

Palæoctonus appalachiensis,
" *aulacodus*,
Clepsysaurus veatleianus,
Suchoprion cyphodon,
Belodon caroliniensis,
Cricotus gibsonii,
" *discophorus*,
Lysorophus tricarinatus,
Diplocaulus calamandroides,
Strigilina gurleiana,
Ctenvolvus pusillus,
Orthacanthus quadriseriatus,
and
Archæobelus vellicatus.

Professor Marsh inquired what authority the Society assigned to the dates of publication affixed to its extra copies of papers in the Proceedings distributed by their authors, and how such dates were fixed, urging the importance of established and well understood rules for the government of the practice in such cases.

After much discussion, it was, on motion of Mr. Lesley,

"*Resolved*, That the Secretaries be directed to use, in case of separata or extras, and at the foot of the last page of the same, the phrase 'Printed (such a date)' viz: the date of the day of the completed printing of each memoir."

The Secretary read an imperfect list of fossils collected by Mr. C. E. Hall, Palæontologist of the Survey of Pennsylvania, at Harvey's Five Points, in Westmoreland county, Pa., from a horizon in the Lower Barren Coal Measures, about 300′ below the Pittsburgh Coal and therefore about 2000 feet above the supposed or presumptive top of the Chemung Formation, one of which appears to be *Streptorhyncus Chemungensis*, var. *arctostriatus* of the Chemung Group in the State of New York (see N. Y. Pal. Vol. IV. p. 71), and another, *Ambocœlia umbonata*, var. *gregaria*, does not seem to differ from that found in the Chemung of New York, yet occurs here in great numbers, and in some cases composes almost the whole mass of the rock. These fossils are accompanied by a *Streptelasma* too imperfect to be specified, and by undetermined species of *Chonetes*, *Productus*, *Athyris* and *Cardiomorpha*.*

Professor Frazer made some preliminary remarks upon a hitherto unnoticed trap dyke extending for miles through Lancaster county, in Pennsylvania, into or towards the Welsh Mountain. Its importance arises from the fact that it passes through the Nickel Mine, and through the North Valley Hill, of assumed Potsdam sandstone.

Pending nominations Nos. 840, 841, 842 and new nominations Nos. 843, 844, 845, 846, 847, 848, 849 and 850 were read.

An application for the Coal-slack Premium from John R. Peters, M. E., of Dover, Morris Co. N. J., was received through Mr. Briggs, and referred to the Committee on that subject.

A form of advertisement suggested by Mr. Fraley to the Secretaries was referred to their consideration.

Mr. Briggs, who objected to certain expressions, moved the following resolution, which was referred to the Board of Officers, after the word "approved" had been struck out with the consent of the mover.

* See note p. 280.

WHEREAS the American Philosophical Society at its meeting on November 11, 1866, passed the following resolution:

Resolved, That the Board of Officers and Council be authorized to offer a premium of Five Hundred Dollars for any successful process by which Anthracite Coal Dust may be economically utilized, such premium to be competed for and awarded in such manner as the Board of Officers and Council may designate, and the premium if awarded to be paid out of the accumulated income of the Magellanic Premium Fund, and

WHEREAS, the American Philosophical Society as custodian of the Magellanic Fund as well as in its character as a Scientific Institution should take every precaution that the premium, if granted, should be given to such person or persons as may establish their right to the same, both on the merits of their claim and by their title as claimants, therefore

Resolved, That the Board of Officers and Council be requested to designate the manner of the competition and award for the instruction of the Committee and of the several applicants in the following regards:

1st. As to the process—Where a claim is based on any alleged invention or discovery, the priority or originality must be proved to be with the claimant to allow him to be considered entitled to the premium.

2d. As to the successful process—When the claim is founded upon the introduction and bringing into general public use well-known processes, the commercial or mechanical importance of which have heretofore been unappreciated, the instrumentality of the person or persons claiming, in effecting the result will be investigated, both as regards other claimants, if any, and also as against others who may not have applied for the premium in order that the premium may not be awarded in default improperly.

3d. As to economical utilization—It must be proved to the satisfaction of the Society that the particular process on which the premium is claimed, shall not only have operated successfully as a process both experimentally and in practice, but shall have so utilized anthracite coal dust as to have given a merchantable value to the same in the general markets for anthracite coal, or shall have demonstrated the economic substitution of dust for other coal in so large quantities as to materially aid the manufacturing industries of the country.

4th. The Board of Officers and Council are also requested to so regulate the conditions of the award that by no possibility any allegation of favoritism can be made, should the premium fall to a member of the Society.

The form suggested by Mr. Fraley and referred to the Secretaries, reads as follows:

"Mr. John E. Wootten having claimed the premium of five hundred dollars offered by the American Philosophical Society for a successful process for utilizing the waste material commonly known as coal dust, and a Committee of the Society having reported that his process is successful and meritorious, notice is hereby given that the Society will award such Premium to Mr. John E. Wootten on the Friday in February, 1878, unless

before that date satisfactory proof shall be given to the Society that the process of Mr. Wootten has been invented and successfully put in use by other parties prior to the date of his patent therefor.

"Such proof must be in writing and be filed before February 1, 1878, with the undersigned, one of the Secretaries of the Society, at the Hall, No. 104 South Fifth street, Philadelphia.

"Insert in two daily papers a week for six weeks."

The Treasurer having announced to the Society that $4,000 of the United States 5-20 loan had been called in—On motion, it was

Resolved, That the Treasurer of the Society, J. Sergeant Price, be authorized under the seal of the Society, to sign the necessary transfer of the $4,000 U. S. Loan called in by the Government, and receive the proceeds thereof.

Resolved, That the Treasurer be authorized to re-invest the proceeds of the U. S. Loan about to be paid off under directions of the Finance Committee of the Society.

The following letter to the Curators respecting the Peale Collection was laid before the Society:

ACAD. NAT. SCIENCE, PHILA., October 25, 1877.

Hector Tyndale, Esq., Charles M. Cresson, M.D., Curators of the Amer. Phil. Society.

GENTLEMEN:—I have had the pleasure to receive your communication of the 18th inst., authorizing the transfer of the Peale Collection of relics of the Stone age to the custody of this Academy, on condition that the said collection shall be returned to the American Philosophical Society on demand.

After the transfer has been made a receipt for the collection will be given.

Very respectfully,

W. R. W. RUSHENBERGER,
Pres. Acad. Nat. Sci. of Phila.

And the meeting was adjourned.

Stated Meeting, November 16, 1877.

Present, 16 members.

Vice-President Mr. FRALEY in the Chair.

Visitor Mr. Hendricks.

A letter was received from the Academy of Natural Sciences of Philadelphia, announcing that they had received

"a Collection of specimens of the Stone Age of the Human Race, as collected and arranged by Franklin Peale," deposited by the American Philosophical Society in the Cabinet of the Academy, upon condition of being returned on demand.

Letters of acknowledgment were received from the K. K. Ast. Obs. Prag, October 18, 1877 (95, 97, 98); R. Obs. Brussells, October 19, 1877 (Trans. O. S. 6 Vols; N. S. I, II, III, V, X to XIII, and Proceedings Nos. 7, 13, 62, 96, 98, 99); R. Geological Soc. of Ireland (99).

A letter was received from D. H. Scheffler, dated Braunscheig, September 25, 1877, asking permission to make a donation to the Library of his work on Physics, the first two parts of which were lain upon the table.

Donations for the Library were received from the Mining Bureau, Melbourne; F. Holmgren, Prof. Phys. Upsal; Prussian Academy; D. H. Scheffler; Flora Batava; Geographical Society, Annales des Mines, Révue Politique, Paris; London Nature; Boston Nat. Hist. Society; Am. Journal S. & A.; Acad. Nat. Sciences, Franklin Institute, College of Pharmacy, Med. News, Penn Monthly, Philadelphia; U. S. War Department, and Engineer's Dept. U. S. A. Washington; and the Meteorological Observatory at Mexico.

Mr. Eli K. Price read the first portion of a paper on Sylviculture. See page 197.

Proceedings of the last meeting of the Board of Officers and Council were submitted.

Pending nominations Nos. 840 to 850 were read.

Mr. Fraley reported the receipt of the quarterly interest on the Michaux Legacy, due October 1st, and its payment to the Treasurer.

Dr. Cresson offered the following resolution:

Resolved, That the Curators be directed to make arrangements for the deposit of the collections of Mexican, Peruvian and other Relics belonging to the Society in the Academy of Natural Sciences, under agreement that the said collections shall be returned on demand.

The motion was seconded and agreed to.

PROC. AMER. PHILOS. SOC. XVII. 100. 2H. PRINTED FEB. 5, 1878.

Prof. Frazer offered the following resolution:

WHEREAS, The prosecution of certain lines of original research simultaneously by a number of able observers has led to confusion as to the authors of specific names to whom the merit of discovery should be assigned, and

WHEREAS, There seems to be a difference of understanding the term publication, and

WHEREAS, It is earnestly desired by the workers in the above-mentioned fields that the date allowed to a description of a species should be as soon as possible after the discovery which that description implies, therefore

Resolved, That this Society will accept as the date of the discovery of a species the date at which a careful and comprehensive abstract of such discovery or discoveries shall have been published in any public journal or magazine,

Provided, That the terms of the abstract shall sharply and distinctly define what has been discovered, and how far these discoveries may be considered by their author to affect scientific questions, and

Provided, That no additions or modifications of such abstract be permitted.

On motion, the above preamble and resolution were referred to the Secretaries.

And the Society was adjourned.

Stated Meeting, December 7, 1877.

Present, 11 members.

Vice-President Mr. FRALEY in the Chair.

Letters of acknowledgment were received from the R. S. New S. Wales, Sydney, October 12 (96); K. K. Geol. R. Vienna, November 4 (99); Royal Ast. S., London, November 12 (99); Radcliffe Observatory, Oxford, October 4 (99); and Dr. Siemens, Westminster, S. W. London, September 27 (97, 98, 99).

Letters of envoy were received from the K. K. Hoffbuchhandlung, Wien, Graben 27, October 30, asking exchanges; N. Gesell, Freiberg i. B. August 8; the Batavian Society, Rotterdam, May, 1877; and the Holland Society at Harlem.

Donations for the Library were received from Mr. John

Tebbut, Sydney; K. K. G. R. Vienna; K. K. Hof, Vienna: K. P. Acad., and D. Geol. G. Berlin; Meteor. Obs., Dorpat; the Societies at Halle, Freiberg i. B., Harlem, Rotterdam and Leeds; R. Institute at Venice; Révue Politique; London Nature; R. Asiatic Society; R. Geog. Society; Met. Com. R. S.; Yale College; College of Pharmacy; and E. D. Cope; U. S. Coast Survey; Mexican Observatory; and Editors of Gazeta Cientifica at Venezuela, Caraccas.

Mr. Price continued the reading of his paper on Sylviculture.

Mr. Blasius read a communication on the cause of the loss of the U. S. ship Huron. See page 212.

Mr. Blasius postponed the reading of another paper, entitled "Modern Meteorological Method" to the next meeting.

The Treasurer's Annual Report was read.

Pending nominations Nos. 840 to 850 were read.

The following Report of the Secretaries on Prof. Frazer's Resolutions was read:

"The Secretaries having considered the Resolution offered by Prof. Frazer, November 16, 1877, respectfully report that in their opinion the action of the Society at a recent meeting, ordering the Secretaries to cause the date of each paper published in the Proceedings to be printed at the foot of the page, is sufficient for all purposes respecting the right of priority to authors of said papers and that no further action need be taken by the Society.

In explanation of this report a letter from Dr. LeConte was read, referring to the printed Rules of Nomenclature adopted by the Entomological Club, Cambridge, July 3, 1877, and papers by Dr. LeConte published in the Canadian Entomologist, October, 1874, and November, 1874, entitled "On some changes in the Nomenclature of North American Coleoptera," &c., and "On Entomological Nomenclature."

The consideration of the subject was, in Prof. Frazer's absence, postponed to the next meeting.

The following is the text of the letter:

Illness prevents me from being present at the meeting of the Society this evening, and I must therefore write what I wish to say in favor of the report of the Secretaries upon the resolutions offered by Prof. Frazer, at the last meeting.

The definition of what constituted a proper publication of a generic or

specific description of an organic form is a question which concerns naturalists alone (i. e. botanists and zoologists), and is not properly a subject to be dealt with by any other class of men of science.

It is, moreover, a question to be determined in the interests and convenience of science alone, and in such manner as to promote its progress by investigators, without reference to the supposed honor of discovery, personal property in the name, or any other of the selfish generalities, under which bad and hasty work are too often covered, and subsequently excused.

The subject has occupied the serious attention of the most eminent naturalists in all countries for many years, and there is likely to be with patience and mutual forbearance among the extremists, an accord of feeling, to be arrived at within a short time.

To show the extremely cautious manner in which it has been approached by societies and persons devoted exclusively to but a single branch of zoology I append the report of a committee of the entomologists of the United States and Canada upon nomenclature, which has progressed to its present form only after two years of active correspondence and consultation. The Secretary will have the kindness to read the appropriate portion of the report. I send too a copy of a short essay by myself, asking attention to a marked passage on p. 205, as embodying in a condensed form my convictions of the motives with which every investigator in science should labor for the best interests of the department of knowledge he has chosen.

"*It is the privilege*, with the facilities for publication now afforded by learned societies, of every careful observer of nature to contribute valuable material for the progress of the branch of science which he is capable of cultivating. *It is his duty* to put his contributions to knowledge in such a form as to be most easily available to his brothers in science. Whether his name remains connected permanently with his observation or not is a matter of small importance; he has done his duty in increasing the power of work of his colleagues."—*Canadian Naturalist, p.* 205.

For these reasons and for many others, which I might specify if time permitted, I think it would be most inexpedient for the Society to express an opinion upon what may constitute a proper scientific publication of supposed new genera and species.

J. L. LECONTE, *Secretary.*

PHILADELPHIA, Dec. 7, 1877.

P. S.—I have received within a few days a pamphlet from Mr. J. Putzeys, of Brussels, which exemplifies both his courtesy to other investigators in the same field, but also the care with which European Societies will guard any attempt to take advantage of the facilities for publication afforded by them. The pamphlet in question is a laborious and conscientious monograph, containing descriptions of one hundred and eleven species, of which 66 are new. This memoir *is to be* published in the Stettiner Entomologische Zeitung for 1878, and the separata of the author, though in his hands for distribution before the middle of November, 1877, bears the same date,

1878. Let this most venerable and time-honored Society err, if there be error, rather on the side of courtesy, than sanction in the slightest degree indecent struggles for priority in giving names to but partially recognized and vaguely studied objects.

The Secretaries reported the following form of advertisement ordered by the Society:

"The American Philosophical Society hereby offer a premium of five hundred dollars for the best successful process by which Anthracite Coal Dust may be economically utilized, the said premium to be competed for and awarded after due examination and report by a Committee appointed for the purpose. Applicants for this premium are requested to file with this Society, within three months, the proofs: 1st of the originality of their inventions, and 2d, of the successful practical working of these inventions. All applications to be sent to the Hall of the A. P. S., 104 South Fifth street, Philadelphia."

"J. P. LESLEY."

This advertisement was, on motion of Mr. Price, adopted and ordered to be published once a week for four weeks in the Scientific American.

On motion of Mr. Price it was

Resolved, That 1000 extra copies of the address on Sylviculture be printed for distribution, out of the Michaux income.

On motion of Mr. Price it was

Resolved, That $40 be appropriated out of the Michaux income to purchase a copy of Michaux & Nuttall's American Sylva for Fairmount Park Library to be presented to the Commissioners of Fairmount Park for the use of the Landscape Gardener.

And the meeting was adjourned.

Stated Meeting, December 21, 1877.

Present, 18 members.

Vice-President, MR. FRALEY, in the Chair.

Mr. H. Phillips, Jr., a newly elected member, was introduced to the presiding officer and took his seat.

Letters of acknowledgment were received from the Vienna Geographical Society, Nov. 22 (97); Physical Society at Geneva, Sept. 15 (96, 97, 98); Central Bureau of

Statistics, Stockholm, Sept. 24 (96–99); and Prof. Rokitansky.

Letters of envoy were received from the Verein für Erdkunde, at Halle an der Saale, Nov. 18, asking for exchanges. On motion this Society was placed on the list of correspondents to receive the Proceedings.

Also from the Physical Society at Geneva, Sept. 15; Central Bureau of Statistics, Stockholm, Sept. 24; Meteorological Office, London; and the U. S. Coast Survey.

A letter was received from the Royal Institution, G. B., Albemarle street, London, Nov. 22, acknowledging the receipt of Proc., No. 88, and asking for the completion of their sets of Proceedings and Transactions of the A. P. S., which on motion was granted (Proc. 69, and Trans. N. S. Vols. III to XI, inclusive, and XIV, ii).

The report of the Secretaries on Prof. Frazer's resolutions made at the last meeting, was on motion, concurred in.

Prof. Prime read a paper "On the Palæozoic Rocks of Lehigh and Northampton counties, Pa." See page 248.

Prof. Frazer followed with remarks on similar rocks in his district of York and Adams counties, and exhibited some artificial brown hematite iron ore in the form of a precipitate from pyrites.

Mr. Lesley exhibited, in illustration of one of the subjects of Prof. Prime's paper, some fine crystals of calcite enclosed in shells of brown hematite, obtained by Mr. Joseph Revere, of Canton, Mass., from a magnesian limestone cave back of St. Genevieve, below St. Louis, Missouri.

Mr. Blasius read his postponed paper on Modern Meteorological Method; and referred to another on certain meteorological facts and problems discussed by him at meetings of this Society.

Mr. Blasius called attention to the gradual adoption of his views by prominent meteorologists without proper acknowledgment of their indebtedness. Some of those views were promulgated as long ago as 1851. He had taken especial pains to publish them and to circulate them by private correspondence with other workers in this field of research, so that there seemed to be no excuse for any attempt to withhold the recognition which

is his just due. He had repeatedly pointed out defects in the present prevailing methods of weather-study. Recent papers in scientific journals and discussions before learned bodies had shown that the same investigator could draw entirely opposite conclusions from the same set of observations.

His reclamation was meant to cover the frequent effect of rain in increasing the force of storms; the influence of the uneven distribution of heat, both in vertical and lateral directions; the mingling of cold and warm air through the alternate encroachment of polar and equatorial currents, the former passing under, or the latter flowing over its antagonist; the consequent occurrence of high barometer storms as well as of low barometer storms; and the fact that the areas of both high and low barometer are parts of the same storm.

He had aroused the attention of meteorologists to the fact that dangerous storms not only might be both preceded and followed by rain, but might be wholly unaccompanied with rain; and these new views had entirely changed the character of the published official and unofficial weather reports and predictions; but he especially insisted on the fact that the methods of observation and correllation in regard to storms, employed by professional meteorologists were still so defective that any hypothesis whatever could be constructed from the present weather charts, at the will or fancy of a meteorologist who had no better resource of his own in the shape of facts of his own observing.

Dr. Sadtler read by title two papers entitled, "A new method for the decomposition of chromic iron," and "Precipitation of copper and sodium carbonate." By Edgar T. Smith, Ph. D., Assistant in Analytical Chemistry, University of Pennsylvania. Being contributions from the Laboratory of the University of Pennsylvania, No. XII. See page 216.

Mr. Lesley exhibited a diagram of the railway cutting, opposite Harrisburg, in Cumberland County, showing the altitude and order of forty-six (46) consecutive layers of the Magnesian Limestone Formation, No. II (calciferous auroral, or siluro cambrian); and a colored diagram of the analysis of said beds, made by Mr. Joseph Hartshorne, in the Laboratory of the Second Geological Survey at Harrisburg, exhibiting a remarkable regular alternation of magnesian and non-magnesian layers, with maxima of insoluble matters corresponding with the maxima of carbonate of magnesia. See page 260.

Prof. Cope displayed life size drawings of vertebræ, femoral and other bones of gigantic fossil saurians of the genera La-

marasaurus, and Amplicœlias (*Camarasaurus supremus*, *Amplicœlias altus*, and *A. latus*), and gave their detailed descriptions in a paper entitled:

"On the Vertebrata of the Dakota epoch of Colorado. By E. D. Cope," with two others: viz. (see page 193).

"Descriptions of New Vertebrata from the Upper Tertiary formations of the West. By E. D. Cope;" (see page 219).

"On some saurians found in the Triassic of Pennsylvania by C. M. Wheatly. By E. D. Cope;" (see page 231).

Prof. Frazer exhibited two framed plaster casts of the Arms of Lord Baltimore, restored from half destroyed sculptures on the mile stones of Mason & Dixon's boundary line between the States of Pennsylvania and Maryland.

The Report of the Finance Committee was read and the recommendations contained therein adopted.

On the recommendation of the Finance Committee in their report, the following resolution was adopted, viz:

Resolved, That the Committee of Finance be authorized and directed to take the needful steps for the sale of the French rentes now held as an investment for the Michaux Legacy and when the proceeds are received into the treasury to make an investment thereof here in such securities as are designated by law for the investment of trust funds.

Pending nominations 840 to 850, and new nominations 851, were read.

And the meeting was adjourned.

NOTE TO PAGE 270.—Prof. Stevenson in a private letter dated January 15, 1878, writes that in the Crinoidal Limestone of the Barren Measures *Spirifer planoconvexa* is characteristically abundant, and has the same mode of occurrence in the rock, which *Ambocoelia umbonata* has in the Chemung, but should not be mistaken for it.

ERRATA for Proceedings A. P. S. Vol. XVI. No. 99.

On page 624, line 12, *substitute* "that of the Sun, and the light received from it 75 times that received from A 61 Cygni, we obtain the following relations:" &c.

On page 625, line 25, *for* "fact of" *read* "fact that."

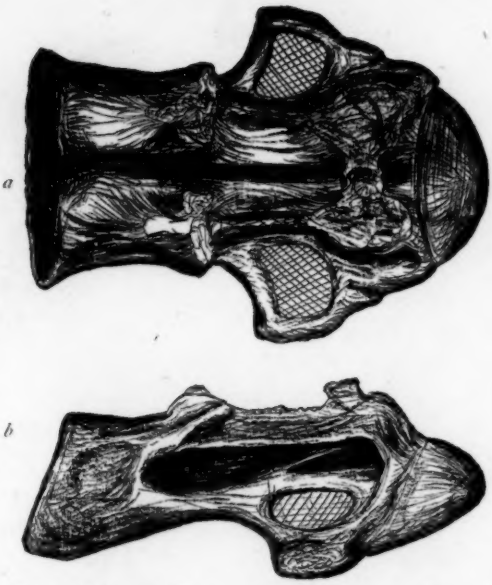


Fig. 1—Cervical vertebra of *Camarasaurus supremus*. *a* from above; *b* from right side. The neural arch is mostly wanting. These figures, like all the others in this paper, are one-tenth natural size.

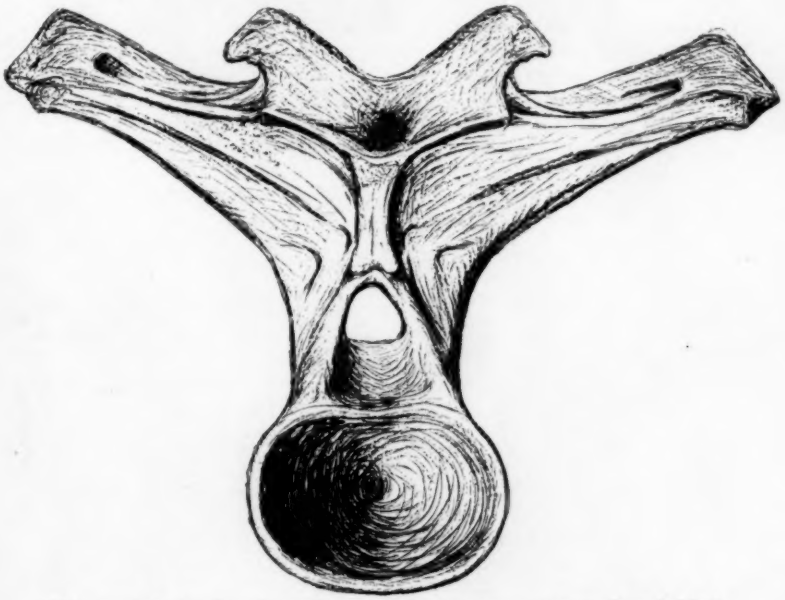


Fig. 2—Anterior dorsal vertebra of *Camarasaurus supremus* from behind.

Fig. 4. Fig. 3.

Fig. 3—Dorsal vertebra represented in Fig. 1, the right sight side. Fig. 4 —A caudal vertebra viewed from behind.

Fig. 7.

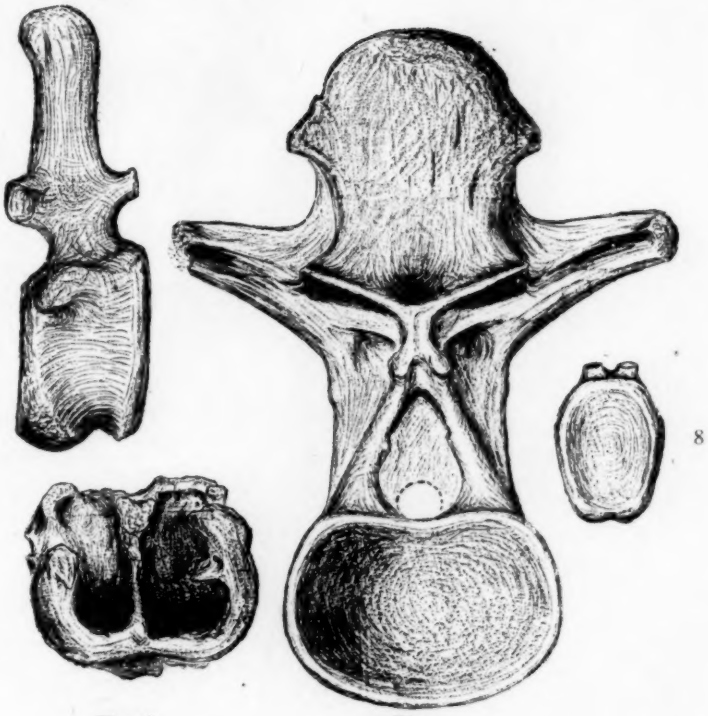


Fig. 6. Fig. 5.

Fig. 5—A median dorsal vertebra seen from behind, showing the hyposphen. Fig. 6—Centrum of a dorsal vertebra without anterior wall. Fig. 7—Caudal vertebra shown in fig. 4, from the right side. Fig. 8—A more posterior caudal, end view of the centrum.

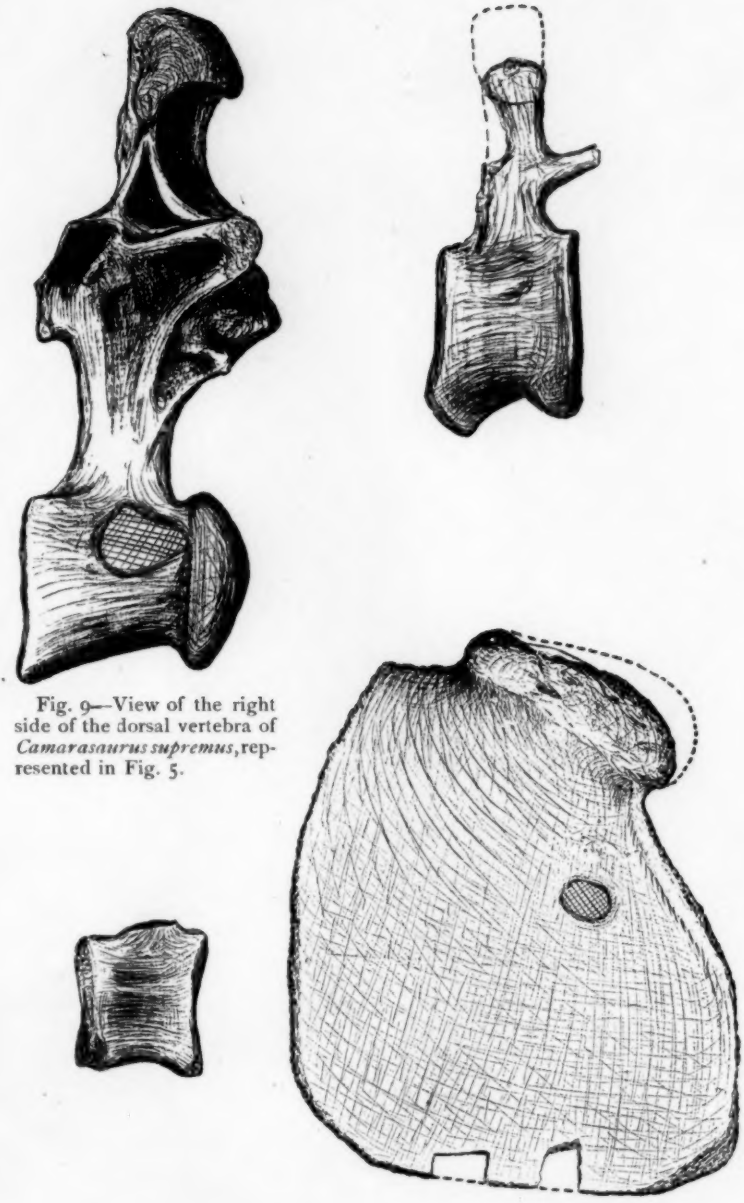
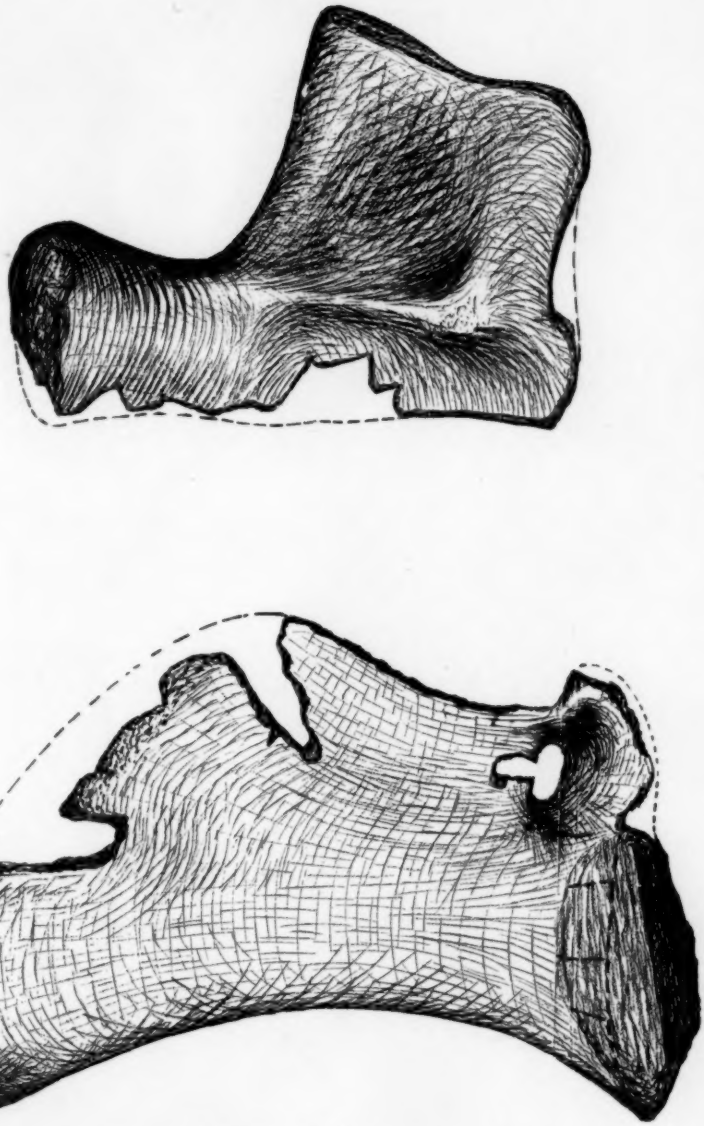


Fig. 9—View of the right side of the dorsal vertebra of *Camarasaurus supremus*, represented in Fig. 5.

Fig. 10—The right scapula of *Camarasaurus supremus*, external view, $\frac{1}{10}$ natural size.



Figs. 11, 12—Pelvic bones of *Camarasaurus supremus*.

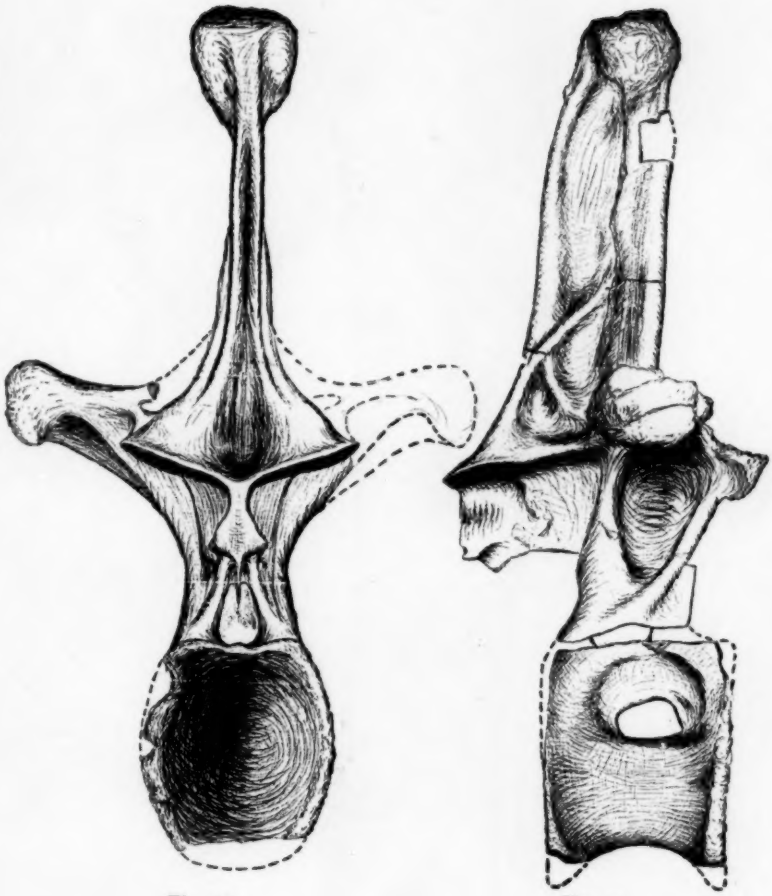
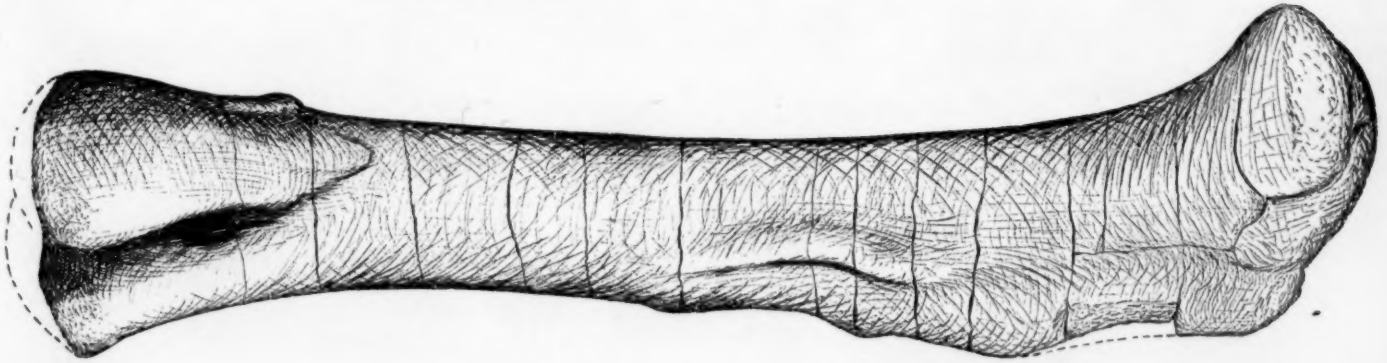


Fig. 13. Fig. 14.

Fig. 13—Dorsal vertebra of *Amphicœlias altus* seen from behind, exhibiting the hyposphen.

Fig. 14—The vertebra represented in Fig. 13 seen from the right side, displaying the excavations of the neural arch and spine, and the pneumatic foramen of the centrum.

Fig. 15—Femur of *Amphicœlias altus*, seen from the inner posterior direction.



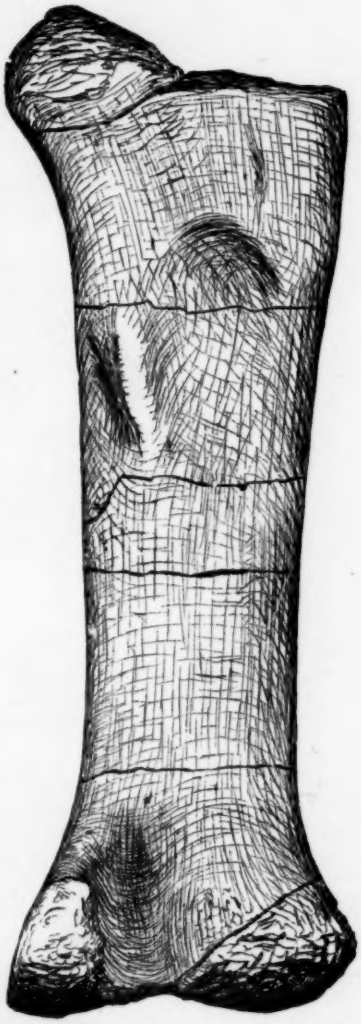


Fig. 17—Left femur of *Amphicœlias latus*, from behind.

Fig. 16—A caudal vertebra of *Amphicœlias latus*; *a* from before, *b* from the left side.

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